PB-215 487

INTERSTATE AIR POLLUTION STUDY PHASE II PROJECT REPORT. VIII. A PROPOSAL FOR AN AIR RESOURCE MANAGEMENT PROGRAM

J. D. Williams, et al

National Center for Air Pollution Control
Cincinnati, Ohio

May 1967

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 215 487

INTERSTATE AIR POLLUTION STUDY

BI-STATE DEVELOPMENT AGENCY

ST. LOUIS DEPARTMENT OF HEALTH AND HOSPITALS

ST. LOUIS - DIVISION OF AIR POLLUTION CONTROL

EAST ST. LOUIS - AIR POLLUTION CONTROL COMMISSION

ST. LOUIS COUNTY HEALTH DEPARTMENT

EAST SIDE HEALTH DISTRICT

MISSOURI DIVISION OF HEALTH

ILLINOIS DEPARTMENT OF PUBLIC HEALTH

CHAMBER OF COMMERCE OF METROPOLITAN ST. LOUIS

ILLINOIS AIR POLLUTION CONTROL BOARD

DHEW
PUBLIC HEALTH SERVICE

PHASE II PROJECT REPORT

VIII. A PROPOSAL FOR AN AIR RESOURCE MANAGEMENT PROGRAM

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

140

INTERSTATE AIR POLLUTION STUDY
PHASE II PROJECT REPORT

VIII. A PROPOSAL FOR AN AIR RESOURCE MANAGEMENT PROGRAM

Prepared by

J. D. Williams

G. Ozolins

J. W. Sadler

J. R. Farmer

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service
Bureau of Disease Prevention and Environmental Control
National Center for Air Pollution Control
Cincinnati, Ohio

May 1967

I

ACKNOWLEDGMENTS

Volume VIII of the Interstate Air Pollution Study Phase II Project Report, although prepared by J. D. Williams, G. Ozolins, J. W. Sadler, and J. R. Farmer, is the product of contributions from all participating project agencies and many individuals. Several of the original ideas and approaches submitted were incorporated into the report. The Division of Air Pollution, Technical Assistance Branch staff helped develop and clarify numerous ideas and concepts, and reviewed the report in several stages. The individuals who have contributed are too numerous to mention by name, but their contributions were in all cases significant. All should gain a sense of satisfaction from the role this report plays in helping the people of the St. Louis Metropolitan Area reach their clean-air goals.

FOREWORD

The Interstate Air Pollution Study was divided into two phases. Phase I, a general study of the overall air pollution problems in the St. Louis - East St. Louis Metropolitan area, was conducted to determine specific activities that would require further study in Phase II of the project. The effort was divided into two phases to provide a logical stopping point in the event that interest and resources for proceeding further might not materialize. The necessary impetus did continue, however, and the Phase II operation was also completed.

The Phase I operation resulted in a detailed report, designed primarily for use of the Executive Committee members and their agenices in making decisions concerning the Phase II project operation. A Phase I summary report was also prepared; it received wide distribution.

Numerous papers, brochures, and reports were prepared during Phase II operations, as were some 18 Memorandums of Information and Instruction concerning the project. All of these documents were drawn upon in the preparation of the Phase II project report. It consists of eight separate volumes under the following titles:

I. Introduction
II. Air Pollutant Emission Inventory
III. Air Quality Measurements
IV. Odors - Results of Surveys
V. Meteorology and Topography
VI. Effects of Air Pollution
VII. Opinion Surveys and Air Quality Statistical Relationships
VIII. Proposal for an Air Resource Management Program

The Project Executive Committee has prepared and approved a technical plan for an air resource management program. It represents a majority view of the agency representatives composing the Executive Committee, but does not necessarily indicate acceptance of all items by all representatives or agencies cooperating on the project.

It is realized that some of the air pollutant sources will be unable to comply with the recommended standards because of economics and lack of technical development; therefore, provision for variance should be provided to avoid unnecessary burden on such sources.

Preceding page blank

Clean air is an economic good that, once attained, is enjoyed by everyone in an air pollution basin. It seems reasonable that the cost of obtaining clean air should be shared by everyone enjoying the benefit. Unfortunately this ideal is not feasible because control equipment cannot and should not be publicly owned, nor can the knowledge for limiting pollutant emissions be a monopoly of government. To assist in establishing a degree of equity it is therefore suggested that tax benefits be given those sources that must purchase pollutant controls, in proportion to these expenditures. These benefits should be given at any or all appropriate levels of government - local, state, or Federal.

CONTENTS

RECOMMENDATIONS 1

INTRODUCTION 3

AIR-USE PLANS 6
  Introduction 6
  Air-Use Plan - Particulates 8
    Air-Quality Goals 9
    Existing Air Quality 9
    Existing Emissions 10
    Relationship Between Air Quality and Emission Density . . . 14
    Land Use and Allowable Emission Densities 18
    Emission Reduction Plan. 18
    Impact of Proposed Regulation on Existing and New Emissions 30
    Special Applications of the Emission Reduction Plan 32

  Air-Use Plan - Sulfur Dioxide 32
    Air-Quality Goals 33
    Design Period 33
    Relationship of Air-Quality Goals to Design Period Concentrations 34
    Existing Concentrations 35
    Existing Emissions 38
    Relationship of Emission Density and Air Quality. 43
    Allowable Emission Density 45
    Emission Reduction Plan. 46

  Air-Use Plan - Hydrocarbons 54
    Air-Quality Goals 54
    Existing Concentrations 55
    Existing and Projected Emissions. 55
    Emission Reduction Plan 63

  Air-Use Plan - Carbon Monoxide 65
    Air-Quality Goals 65
    Existing Concentrations 66
    Existing and Projected Emissions. 66
    Emission Reduction Plan. 66

  Air-Use Plan - Nitrogen Oxides 68
    Existing Concentrations 68
    Existing Emissions 68

Air-Use Plan - Odors 72
    Existing Conditions 72
    Air-Quality Goals - Odors 74
    Evaluation of Existing Conditions 74
    Odor Reduction Plan 75

Benefits of Rapid Transit System 76

SUGGESTED ORGANIZATION OF INTERSTATE AIR POLLUTION STUDY AREA AIR RESOURCE MANAGEMENT PROGRAM 78

Illinois Program in St. Clair and Madison Counties 79
Missouri State Air Pollution Program 80
Illinois Local Agencies 80
Missouri Local Agencies 81
Interstate Agreement 81
Interstate Coordinating Organization 81

GUIDELINES FOR FUTURE AIR RESOURCE MANAGEMENT PROGRAM ELEMENTS AND FINANCING 82

Continuing Air-Quality and Effects-Monitoring Program 82
Current and Continuing Emission Inventory 83
Air-Quality Goals, Standards and Criteria 85
Use of Conditions Influencing Transport of Air Pollutants 85
Air Pollution Control Decisions Based upon Air-Quality Information and Goals 86
Program Financing 86

REFERENCES 86

APPENDICES 88

A - Particulate Levels Due to Venice Power Plant 88

B - Suggested Ordinance Provisions 89

VIII. A PROPOSAL FOR AN AIR RESOURCES MANAGEMENT PROGRAM

RECOMMENDATIONS

The following summary of major recommendations for an air resource management program is based on the Interstate Air Pollution Study findings reported in Volumes I through VII of this report. The recommendations, developed and explained in detail in this section, Volume VIII, are outlined below.

ORGANIZATION

1. Establish a means for joint air pollution activities, involving local and state agencies, by agreement or compact between the States of Missouri and Illinois.

2. Develop a regional organization covering the Illinois portion of the air pollution basin and delineating appropriate roles for both State and local agencies.

3. Strengthen, improve, and increase air pollution program activities in St. Louis and St. Louis County.

4. Establish a functional linkage between regulatory and urban planning activities directed toward preventing air pollution problems arising from land-use and air-use conflicts, to optimize the air use.

5. Plan for governmental air pollution program expenditures at a level of 50 cents per capita per year by 1970.

ACTIVITIES

1. Implement the following major program elements of an air resource management program in a balanced and coordinated manner but with emphasis on control of pollutants in the immediate future through utilizing the information and data provided by the Study:

   a. A continuing air-quality monitoring program.

   b. A current and continuing emission inventory.

   c. Air-quality goals and standards based on air-quality criteria.

   d. A thorough knowledge and use of the conditions influencing the transport of air pollutants.

   e. Urban planning decisions based on air quality as well as other environmental factors.

f. Air pollution control decisions and resulting ordinances based on air-quality information and relationships between air quality and effects.

g. Air-use plans.

2. Implement the particulate air-use plan by enacting regulations or ordinance provisions to accomplish the following objectives, which are designed to reach the air-quality goal of 75 micrograms per cubic meter as a yearly average at any place where people live or where an undesirable effect might result:

a. Elimination of hand firing of fuels on a gradual basis.

b. Elimination of open burning.

c. Limitation of pollutants from incinerators.

d. Limitation of pollutants from the burning of coal.

e. Limitation of allowable visible pollutants.

3. Implement a vigorous odor control program to eliminate objectionable odors in any residential area.

4. Implement the sulfur dioxide air-use plan by enacting regulations or ordinance provisions to accomplish the following objectives, which are designed to meet an air quality goal of 0.1 ppm for a 24-hour average not to be exceeded over 1 percent of the time in any 100 consecutive days at any place where people live or where an undesirable effect might result:

a. Limitation of the sulfur content of fuels to 2.3 pounds sulfur dioxide per million Btus of heat input for equipment smaller than 2,000 million Btus of heat input.

b. Development of a plan within 2 years, for equipment larger than 2,000 million Btu to meet the limitation of (4a) by some scheduled future date.

c. Limitation of sulfur emissions from industrial processes.

5. Implement the hydrocarbon, carbon monoxide, and nitrogen oxides air-use plans primarily by designing into the proposed mass transit study items that will help prevent undesirable levels of the following:

a. Hydrocarbons.

b. Nitrogen oxides.

c. Carbon monoxide.

d. Oxidants.

e. Aldehydes.

f. Odorous materials (e.g. diesel exhaust).

    g. Particulate matter.

6. Limit emissions of acidic and alkaline pollutants.

7. Limit hydrocarbon emissions by:

    a. Requiring submerged fill pipes on certain new tanks.

    b. Requiring vapor-recovery systems to be installed on certain new tanks.

    c. Requiring refuse disposal methods that will not contribute hydrocarbons to the air.

INTRODUCTION

Benefits are gained by good management practices whether these practices are applied to the home and family, business, or government. The principles are basically the same in each case: a thorough knowledge of resources must be obtained, and plans must be formulated to apply those resources toward achieving specific goals. For example, good business management calls for a knowledge of what is wasted so that wastes can be converted into by-products, materials can be conserved, and new products can be developed. On a somewhat broader scale, knowledge of all wasted solid, liquid, and gaseous materials, lost to the atmosphere as pollutants, could provide the means for optimizing material use and conserving many basic materials. Materials conserved or reclaimed would be used for other purposes and economic gain.

The air, being a basic material for any manufacturing process, combustion process, or for the use of humans in supporting life, can hardly escape the attention due it by present day society. In the past, air was considered God given and free. This attitude is revealed in many expressions of our society, such as "free as the air". Air is not unlimited however, at least in certain geographical areas. This fact is revealed, and has been for many years, by numerous land-use and air-use conflicts. For example, an industry located in a residential area might want to use the air for disposal of wastes, whereas the residents would want the air to be safe for breathing and clean enough to protect their property.

The air is a matter of public business, calling for good management practices. The public must have knowledge of air quality, effects of air pollutants, and the types and quantities of pollutants put into the air. Armed with this knowledge, the public depends on its governmental organizations to establish air quality goals and standards, and to develop the program goals, air-use plans, and action programs needed to reach the desired air quality. Simply stated, the public embarks on an air resource management program to assure sound community growth in which the air resources of the air pollution basin* are put to optimum use. The major program elements of an air resource management program are:

---

* The term "air pollution basin" as used in this report refers to an area in which air pollutants originate and collect, and in which the principal effects of those pollutants occur.

1. A continuing air-quality monitoring program.

2. A current and continuing emission inventory.

3. Air-quality goals and standards based on air-quality criteria.

4. A thorough knowledge and use of the conditions influencing the transport of air pollutants.

5. Urban planning decisions based on air quality as well as other environmental factors.

6. Air pollution control decisions and resulting ordinances based on air-quality information and relationships between air-quality and effects.

The interrelationships between the six program elements are shown in Figure 1, a flow diagram that explains air resource management. Note the central importance of air quality goals and how they relate each program element to the other parts. The goals are based on the effects that air pollutants at particular levels may cause. Effects in turn are related to numerical air-quality levels by criteria - word meanings equated with numbers. These program elements considered within a suitable decision-making process lead to the establishment of goals, which in turn lead to air quality standards, ordinances, rules and regulations, planning decisions, and community purposes and policies. The results are changed levels of air pollution, changes in emissions, and changes in the effects that pollutants cause.

The Interstate Air Pollution Study has presented the information and data needed for initiating an air resource management program in seven major sections of the Study Phase II Project Report. These seven sections were used to prepare this section, which presents recommendations concerning air quality goals, emission limitations needed to reach those goals, and the program organization suitable to assure a viable and continuing program.

For the Interstate Air Pollution Study Area air resource management program to meet its goals, the following points must be agreed to:

1. The air pollution basin must be covered adequately and all listed air resource management activities (program elements) must be carried on to assure complete success.

2. Air-quality goals must be established that will be uniform or that will be uniformly applicable on a meteorological and land-use basis.

3. The air-quality levels as defined by goals will be reached by control of air pollutant sources adequate to prevent air pollutants that cross political or land-use boundaries from causing the goals to be exceeded.

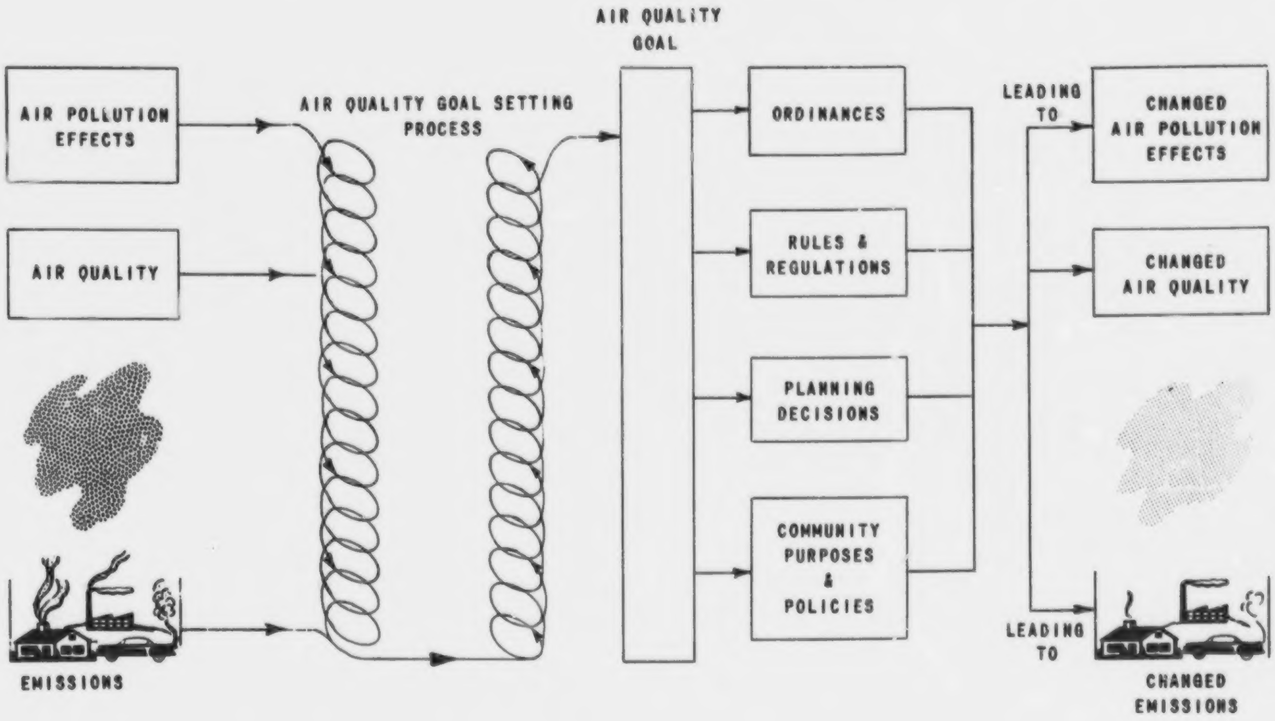

AIR POLLUTION EFFECTS
AIR QUALITY
EMISSIONS
AIR QUALITY GOAL SETTING PROCESS
AIR QUALITY GOAL
ORDINANCES
RULES & REGULATIONS
PLANNING DECISIONS
COMMUNITY PURPOSES & POLICIES
LEADING TO
CHANGED AIR POLLUTION EFFECTS
CHANGED AIR QUALITY
LEADING TO
CHANGED EMISSIONS

Figure 1. Air resource management flow diagram.

AIR-USE PLANS

INTRODUCTION

The basic objective of an air resource management program is to obtain and maintain optimum air quality defined by air-quality goals. These goals for the Interstate Air Pollution Study were selected on the basis of effects. The goals and justification for their selection are reported in Volume VI of this report.

This report section, Volume VIII, is devoted to the development of air-use plans for each of the major air pollutants found in the St. Louis urbanized area. An air-use plan may be thought of as a link between the pollutant emissions of a community and the air-quality goals. The overall function of these plans is to optimize the use of the air by considering the amounts, configurations, and locations of the sources and the dilution capability of the air basin. The air-use plans may be used as the basic framework for achieving the desired air quality by such means as limiting the emissions from individual sources, limiting the emissions from sources in certain areas, or even disallowing new pollutant sources in overburdened areas. The air-use plans thus provide the bases for enacting control regulations and serve as a guide for future planning activities.

The type and configuration of pollution sources, the extent by which the air-quality goals are exceeded, and the meteorology and the topography are peculiar to each urban area. For these reasons, it is unrealistic to expect that common air-use plans and the same control regulations may be applied indiscriminately in any area. Control regulations must be based strictly on the reductions in pollutant emissions needed in each air pollution basin.

The design of an air-use plan consists of two parts. The first part is the calculation of the quantity of pollutants that may be safely emitted and the reductions needed to reach the allowable emission rates. The second part consists of guidelines for achieving these reductions by determining the reductions in emissions needed from specific source categories in certain areas or even from individual sources.

The design of an air-use plan at the present stage of design-system development is complicated by the number and diversity of pollutant sources present in urban areas, the incompleteness of data concerning emission rates and release heights and the uncertainty of knowledge concerning the diffusion characteristics of the atmosphere. In the effort to determine the dilution capacity of the atmosphere in the Study area, it was necessary to employ several simplifying assumptions, some of which have not been fully tested. Until more accurate emission and meteorological data become available and the use of computerized diffusion models capable of considering all the important variables are perfected, the presented techniques and the air-use plans for the St. Louis area will provide an adequate framework for making decisions.

The pollutants considered in this section include particulates, sulfur dioxide, hydrocarbons, carbon monoxide, oxides of nitrogen, and odors; however, comprehensive emission reduction plans have been developed for only particulates and sulfur dioxide. Hydrocarbons, carbon monoxide, oxides of nitrogen, and odors have been considered to a lesser degree. Hydrocarbons and carbon monoxide are emitted primarily by motor vehicles and are expected to be controlled primarily on a nationwide scale and secondarily by changes in the mass transit systems in St. Louis.

Oxides of nitrogen are becoming an increasing problem; however, the limited air-quality data and lack of air-quality goals as the Study was being conducted would not permit a more complete treatment. Because odors are generally associated with individual sources, a comprehensive reduction plan is not workable; therefore, the treatment of odors is discussed only in general terms.

Since the development of a rapid transit system will have a notable effect on the air concentrations of certain pollutants in the St. Louis area, and especially in the downtown areas, its importance as a means to reducing air pollution must not be overlooked. For this purpose a special report section on the impact of a rapid transit system is also included.

In the design of air-use plans, the pollution sources have been classified according to the following land-use categories: residential, commercial, industrial, and open space (including roads). With the land-use designated, the variability in emission sources may be considered and different area emission limitations dependent on land-use may be prescribed. This leads to a more equitable basis for reducing the emissions and permits cleaner air in the places where people live.

Although the Interstate Study covered an area of over 3,500 square miles and included the City of St. Louis and the six surrounding counties, the design of the air-use plans was based on only the centrally located, highly urbanized area of some 394 square miles (Figure 2*). This was done for two reasons. First, this area contains the vast majority of the pollutant sources, and second, the sources located in this area add to the pollution of this area at all times, whereas those located in the surrounding areas do so only under certain meteorological conditions. It would, therefore, be unsuitable in an engineering design sense to consider these sources in the same context. Since, however, the meteorology and topography are similar within this 3,500-square-mile area, the design relationships developed should be applicable to all parts of this area provided emission and air-quality data are collected for those sub areas. In other words, a decision to have ordinances uniform in all parts of the counties in the air pollution basin based on central urbanized area calculations would not be primarily an engineering design decision, but would be a program design decision.

As noted previously, utilization of air-use plans is not limited to setting emission control regulations, but is also applicable in urban planning activities. Future activities should be evaluated with respect to the information presented here since some of the best and least expensive ways of combating air pollution may come

---

* Area maps used in this report are divided into 10,000-foot-square grids. Reference to grid cells by coordinate numbers indicates the grid cell to the north and east of the designated point.

The pollutants considered in this section include particulates, sulfur dioxide, hydrocarbons, carbon monoxide, oxides of nitrogen, and odors; however, comprehensive emission reduction plans have been developed for only particulates and sulfur dioxide. Hydrocarbons, carbon monoxide, oxides of nitrogen, and odors have been considered to a lesser degree. Hydrocarbons and carbon monoxide are emitted primarily by motor vehicles and are expected to be controlled primarily on a nationwide scale and secondarily by changes in the mass transit systems in St. Louis.

Oxides of nitrogen are becoming an increasing problem; however, the limited air-quality data and lack of air-quality goals as the Study was being conducted would not permit a more complete treatment. Because odors are generally associated with individual sources, a comprehensive reduction plan is not workable; therefore, the treatment of odors is discussed only in general terms.

Since the development of a rapid transit system will have a notable effect on the air concentrations of certain pollutants in the St. Louis area, and especially in the downtown areas, its importance as a means to reducing air pollution must not be overlooked. For this purpose a special report section on the impact of a rapid transit system is also included.

In the design of air-use plans, the pollution sources have been classified according to the following land-use categories: residential, commercial, industrial, and open space (including roads). With the land-use designated, the variability in emission sources may be considered and different area emission limitations dependent on land-use may be prescribed. This leads to a more equitable basis for reducing the emissions and permits cleaner air in the places where people live.

Although the Interstate Study covered an area of over 3,500 square miles and included the City of St. Louis and the six surrounding counties, the design of the air-use plans was based on only the centrally located, highly urbanized area of some 394 square miles (Figure 2*). This was done for two reasons. First, this area contains the vast majority of the pollutant sources, and second, the sources located in this area add to the pollution of this area at all times, whereas those located in the surrounding areas do so only under certain meteorological conditions. It would, therefore, be unsuitable in an engineering design sense to consider these sources in the same context. Since, however, the meteorology and topography are similar within this 3,500-square-mile area, the design relationships developed should be applicable to all parts of this area provided emission and air-quality data are collected for those sub areas. In other words, a decision to have ordinances uniform in all parts of the counties in the air pollution basin based on central urbanized area calculations would not be primarily an engineering design decision, but would be a program design decision.

As noted previously, utilization of air-use plans is not limited to setting emission control regulations, but is also applicable in urban planning activities. Future activities should be evaluated with respect to the information presented here since some of the best and least expensive ways of combating air pollution may come

---

* Area maps used in this report are divided into 10,000-foot-square grids. Reference to grid cells by coordinate numbers indicates the grid cell to the north and east of the designated point.

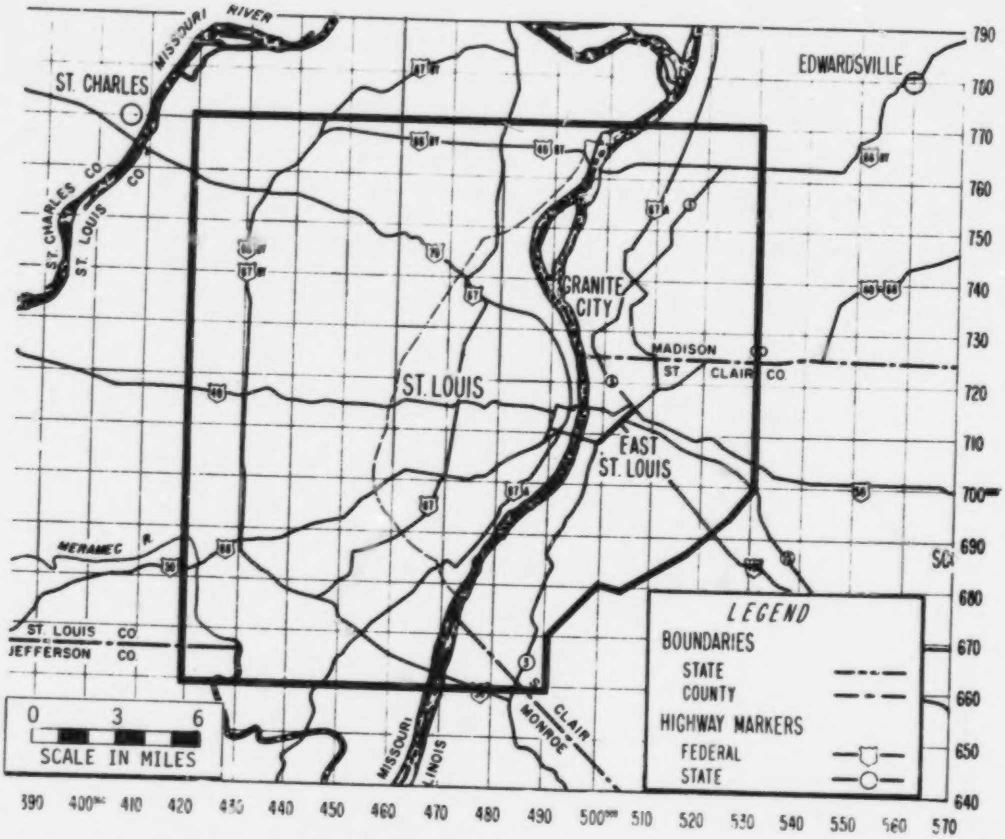

MISSOURI RIVER
ST. CHARLES
EDWARDSVILLE
ST. CHARLES CO.
ST. LOUIS CO.
GRANITE CITY
MADISON
ST. CLAIR CO.
ST. LOUIS
EAST ST. LOUIS
MERAMEC R.
ST. LOUIS CO.
JEFFERSON CO.
CLAIR
MONROE
MISSOURI
ILLINOIS
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
0
3
6
SCALE IN MILES
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570

Figure 2. Location map - central urbanized area of prime interest in Interstate Air Pollution Study.

under the responsibilities of planning and not control agencies. Similarly, information needed to fill the gaps in the presented air-use plans should be collected so that refinement is continuous. For example, information relating to the variation in emission rates with time as well as emission release elevations is needed. Furthermore, accurate and up-to-date land-use data are a necessity for further refinement of the air-use plans.

AIR-USE PLAN - PARTICULATES

Particulate matter is the most common air pollutant in urban areas. The principal sources of this pollutant are the burning of heavy fuels, industrial processes, and refuse disposal by burning. In terms of the quantity of particulate matter emitted to the air, a few large pollutant sources contribute, or have the potential for contributing, more than 50 percent of the area total. Since these emissions are released from much higher elevations than most others, the additional dilution disperses the pollutants over a large area. Smaller sources distributed throughout the area cause many localized problems. In the design of the particulate air-use plan, both types of sources were considered. The plan is developed by using the following items:

1. Air-quality goals.
2. Existing air quality.
3. Existing emissions.
4. Relationship between air quality and emission density.
5. Land-use and allowable emission densities.
6. Emission reduction plan.

Air-Quality Goals

The three measures of particulates - suspended particulates, dustfall, and soiling index - are closely interrelated; therefore, usually if one is reduced, the others are also reduced. Suspended particulate values measured by high-volume filter samplers are the most representative; therefore, these values have been the accepted as the measure of choice for particulate concentrations. Trial calculations have shown that reductions in particulate emissions necessary to meet the suspended particulate goal will probably also result in the achievement of the goals set for the other measures of particulates. The desired goals for suspended particulates as measured by high-volume samplers have been set at:

1. An annual geometric mean concentration of 75 micrograms per cubic meter.

2. Two-hundred micrograms per cubic meter, not to be exceeded for more than 1 percent of days in any 1 year.

These goals are applicable to all areas where people live or an adverse effect may occur. The use of these air-quality goals and subsequent design of the air-use plan for particulates are based on the weight of particulate matter. The particle size distribution and the chemical composition are probably just as important as the weight, but lack of data at this stage of air quality measurement capability does not allow their consideration.

Existing Air Quality

As recorded at the 17 high-volume sampling stations during 1963-1964, the annual geometric mean concentrations of suspended particulates varied from approximately 60 micrograms per cubic meter at one suburban station to more than 220 at a sampling site close to a major source of pollution. From an isopleth map based on these data, the weighted geometric mean for the area was found to be approximately 92 micrograms per cubic meter. Approximate land areas and the mean annual concentration they are subjected to, according to these measurements, are presented in Table 1. The annual geometric mean concentrations of suspended particulates are in excess of 75 micrograms per cubic meter over more than 50 percent of the area, or 200 square miles, and the 99 percentile goal of 200 micrograms per cubic meter is exceeded over almost the entire area. (Figures 3 and 4.)

Table 1. MEAN ANNUAL SUSPENDED PARTICULATE CONCENTRATION BY LAND AREAS IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA

	Land area, mi^2	Percent of total	Mean concentration, $\mu g/m^3$
	21	5	175
	124	32	125
	31	8	92
	41	10	82
	91	23	68
	86	22	60
Central urbanized area	394	100	92

Existing Emissions

Approximately 106,000 tons of particulates, or an average of 269 tons per square mile, is emitted annually to the air of the central urbanized area. The emission densities of particulates range from a few tons per square mile per year in the sparsely populated residential areas to over 5,000 tons per square mile in highly industrialized areas. The primary sources of particulates are the combustion of coal, certain industrial processes, and the open burning of refuse material. A summary of the annual emissions by political subdivisions and source categories is presented in Table 2. Volume II of this report presents emission information in detail.

Table 2. ANNUAL (1963-1964) PARTICULATE EMISSIONS IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA
(tons/year)

Land-use category/ Emission sources	City of St. Louis	St. Louis County[a]	Madison County[a]	St. Clair County[a]	Entire central urbanized area[a]
Industrial	14,450	8,487	23,887	21,199	68,023
Fuel-use	10,619	4,607	12,665	11,333	39,224
Coal	10,522	4,412	12,315	11,248	38,497
Fuel oil	36	138	200	30	404
Gas	61	57	150	55	323
Process emissions	2,664	3,865	10,600	5,544	22,673
Refuse disposal	1,167	15	622	4,322	6,126
Incineration	1,167	15	12	n	1,194
Open-burning	na[b]	na	610	4,322	4,932
Residential	9,689	4,747	4,957	6,143	25,536
Fuel-use	7,569	3,559	3,177	4,213	18,518
Coal	7,273	3,161	3,062	4,089	17,585
Fuel oil	168	243	87	95	593
Gas	128	155	28	29	340
Refuse disposal	2,120	1,188	1,780	1,930	7,018
Incineration	50	28	n[c]	n	78
Open-burning	2,070	1,160	1,780	1,930	6,940
Commercial	3,693	982	503	636	5,812
Fuel-use	3,533	960	503	615	5,609
Coal	3,500	940	500	610	5,550
Fuel oil	19	9	2	4	32
Gas	14	11	1	1	27
Refuse disposal	160	22	na	21	203
Incineration	160	22	na	21	203
Open-burning	na	na	na	na	na
Open space	2,754	1,822	648	1,242	6,466
Transportation	2,754	1,822	648	1,242	6,466
Road vehicles	2,150	1,510	385	415	4,460
Other	604	312	263	827	2,006
Totals	30,586	16,038	29,995	29,218	105,837

[a] Data are from only the portion of the study area included within the 394-square-mile central urbanized area of principal interest in the Study.

[b] na = information not available or reported.

[c] n = negligible.

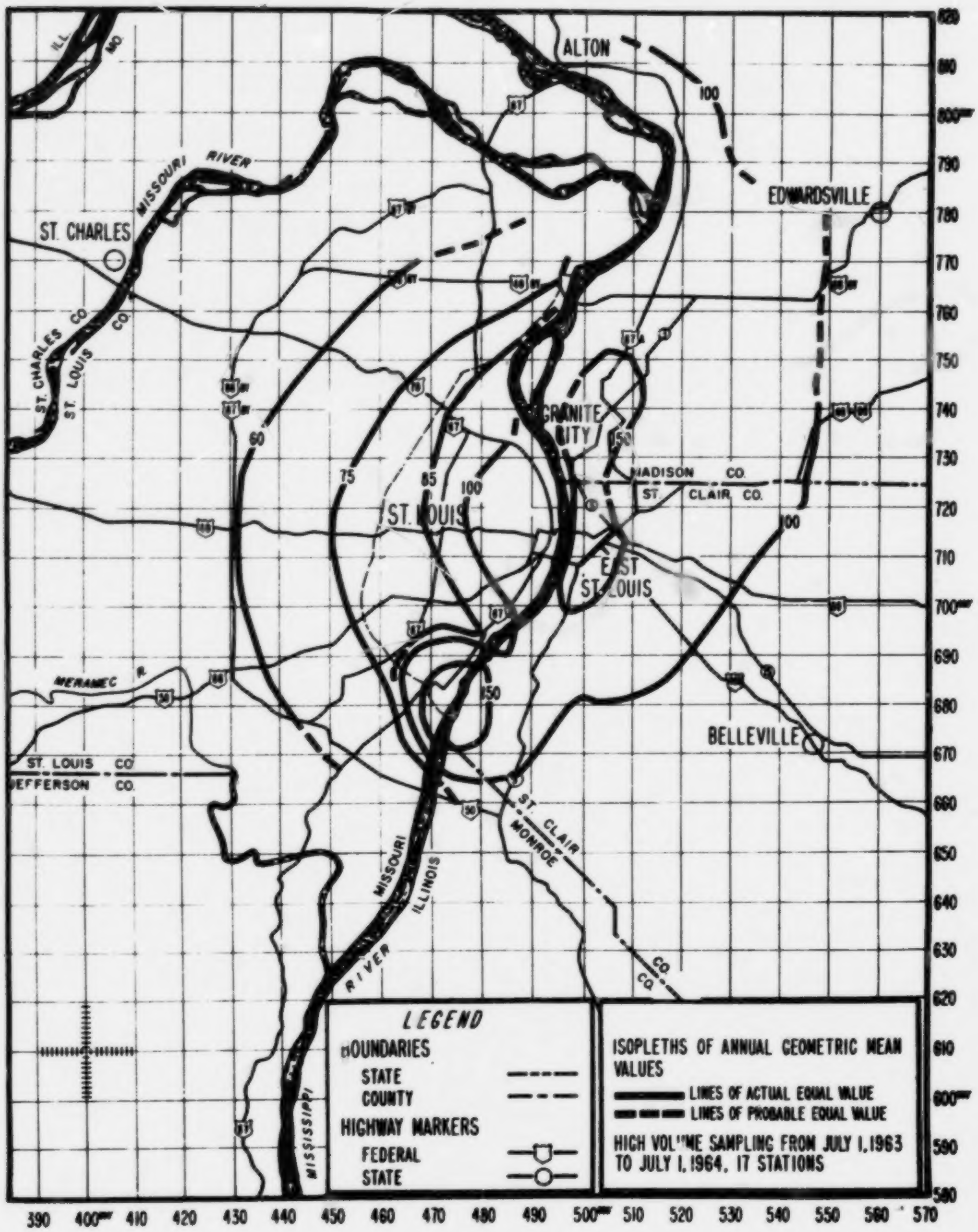
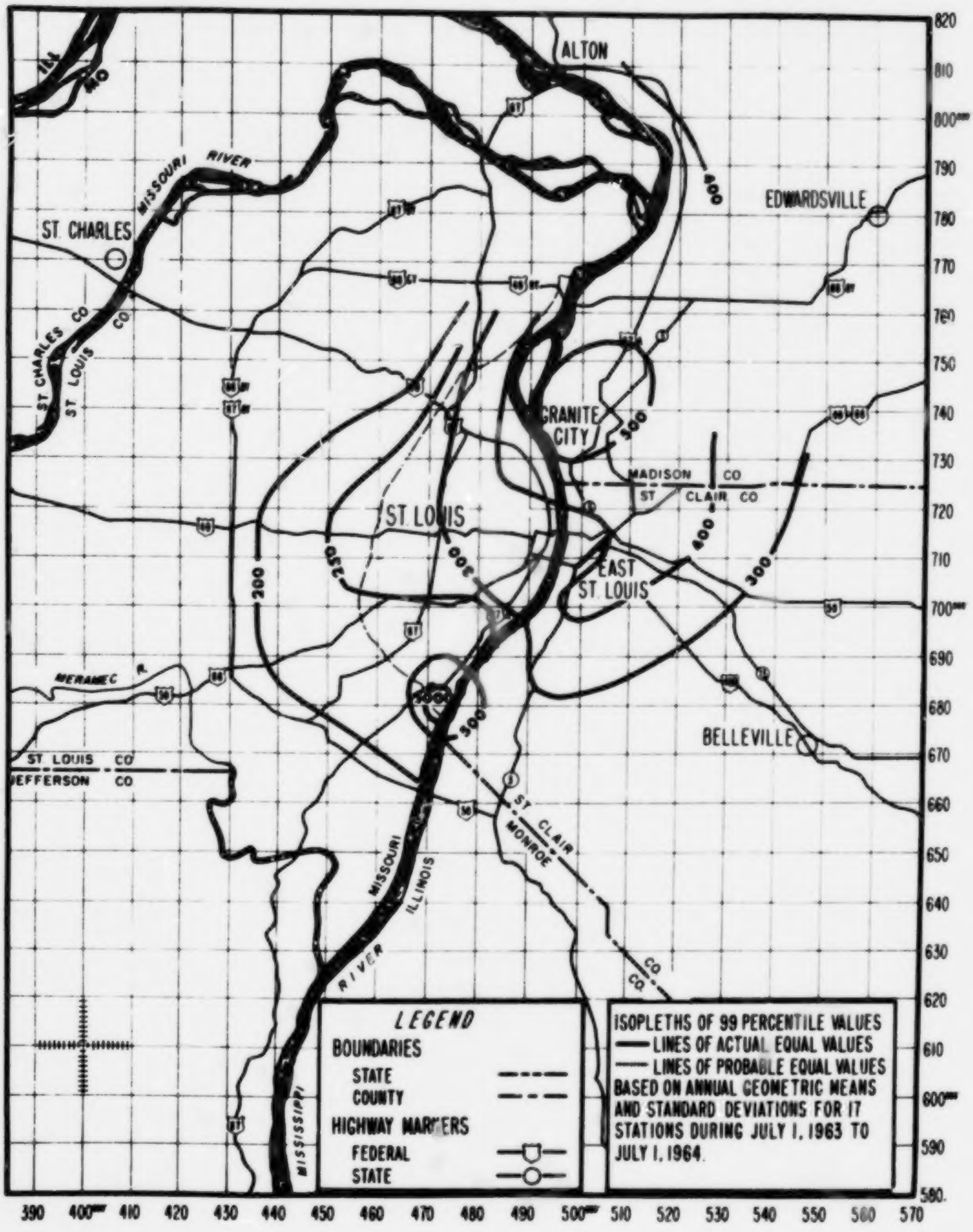

ILL.
MO
ALTON
100
EDWARDSVILLE
MISSOURI RIVER
ST. CHARLES
ST. CHARLES CO.
ST. LOUIS CO.
GRANITE CITY
MADISON CO.
ST. CLAIR CO.
60
75
85
100
150
ST. LOUIS
EAST ST. LOUIS
MERAMEC R.
BELLEVILLE
ST. LOUIS CO.
JEFFERSON CO.
ST. CLAIR
MONROE
CO.
CO.
MISSOURI
ILLINOIS
RIVER
MISSISSIPPI
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
ISOPLETHS OF ANNUAL GEOMETRIC MEAN VALUES
LINES OF ACTUAL EQUAL VALUE
LINES OF PROBABLE EQUAL VALUE
HIGH VOLUME SAMPLING FROM JULY 1, 1963 TO JULY 1, 1964, 17 STATIONS
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570
820
810
800
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580

Figure 3. Annual geometric mean values for suspended particulates measured by high-volume sampler (micrograms per cubic meter).



ALTON
EDWARDSVILLE
ST. CHARLES
GRANITE CITY
ST LOUIS
EAST ST. LOUIS
BELLEVILLE
MISSOURI RIVER
MERAMEC R.
MISSISSIPPI RIVER
MISSOURI
ILLINOIS
ILL
MO
ST CHARLES CO
ST LOUIS CO
ST LOUIS CO
JEFFERSON CO
MADISON CO
ST CLAIR CO
ST CLAIR
MONROE
CO
CO
200
250
300
300
400
400
500
500
600
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
ISOPLETHS OF 99 PERCENTILE VALUES
LINES OF ACTUAL EQUAL VALUES
LINES OF PROBABLE EQUAL VALUES
BASED ON ANNUAL GEOMETRIC MEANS AND STANDARD DEVIATIONS FOR 17 STATIONS DURING JULY 1, 1963 TO JULY 1, 1964.
820
810
800
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570

Figure 4. Annual 99th percentile values for suspended particulates measured by high-volume sampler (micrograms per cubic meter).

Emission densities in industrial areas range from an average 1,060 tons per square mile for St. Louis County to an average of approximately 2,843 tons per square mile for Madison County, with an overall average for the industrial area of 1,890 tons per square mile per year. The emission densities corresponding to other land uses are small by comparison: 255 tons per square mile for commercial land-use areas, 170 tons per square mile for residential, and approximately 35 tons per square mile for other land uses. Although industrial land use constitutes most of the particulate pollutants, it occupies only 9 percent of the land in the central urbanized area. The emission densities corresponding to the different land uses and political subdivisions are given in Table 3. With the exception of the City of St. Louis, the land-use areas listed are only approximations and should be interpreted as such. Open-burning dumps, included in the industrial category because of their location in industrial land-use areas, are also used for the disposal of domestic and commercial refuse material.

Table 3. DENSITY OF PARTICULATE EMISSIONS BY TYPE OF LAND USE IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA
(tons/mi^2/yr)

Jurisdictional subdivision	Land—use category				
	Industrial	Residential	Commerical	Open Space	Total
City of St. Louis	1,460	450	950	108	500
St. Louis County[a]	1,060	52	83	17	74
Madison County[a]	2,843	260	150	28	555
St. Clair County[a]	2,185	290	170	47	482
Central urbanized area	1,890	170	255	35	269

[a] Data are from only the portion of the Study area included within the 394-square-mile central urbanized area of principal interest in the Study.

The heights of emissions vary from 300 feet for the Cahokia Power Plant to practically ground level for backyard burning installations. Nearly all of the residential emissions and most of commercial and industrial are discharged from elevations of less than 120 feet above ground.

Relationship Between Air Quality and Emission Density

As pointed out earlier, the ambient air concentrations of suspended particulates are dependent not only upon the total quantity of particulates emitted to the air pollution basin, but also on the geographical distribution of the emissions, the types of sources, the diffusion capacity of the air pollution basin, and the seasonal and diurnal variations in pollutant emissions. To attain the desired air quality goal, even in the presently most polluted areas, the emission limitations should be considered according to particulate emissions from specific locations in the Study area. Since emission density (tons per square mile) relates to the quantity of particulates emitted to the area, this parameter is used as a basis in setting emission limitations.

It therefore becomes necessary to determine the limiting emission density that would result in the desired air-quality in all parts of the area. By considering several contiguous areas of considerable size and relating their average emission densities to the corresponding ambient concentrations, a relationship between these parameters is obtained. Figure 5 presents the relationship between the annual geometric mean concentration and the corresponding average emission density. This relationship is valid only for areas of considerable size (probably about 20 square miles) where the net effect of pollutant transfer between adjacent areas is relatively minor. The location of the preselected areas and the values used in deriving Figure 5 are presented in Figure 6 and Table 4, respectively.

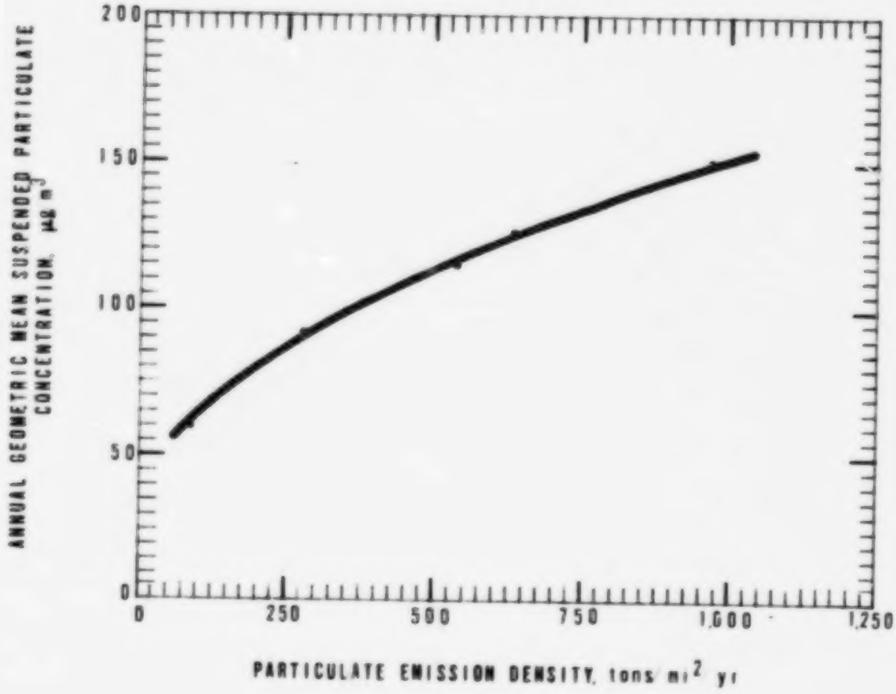


Figure 5. Relationship between emission density and mean annual concentration for any considerable area in St. Louis urbanized area.

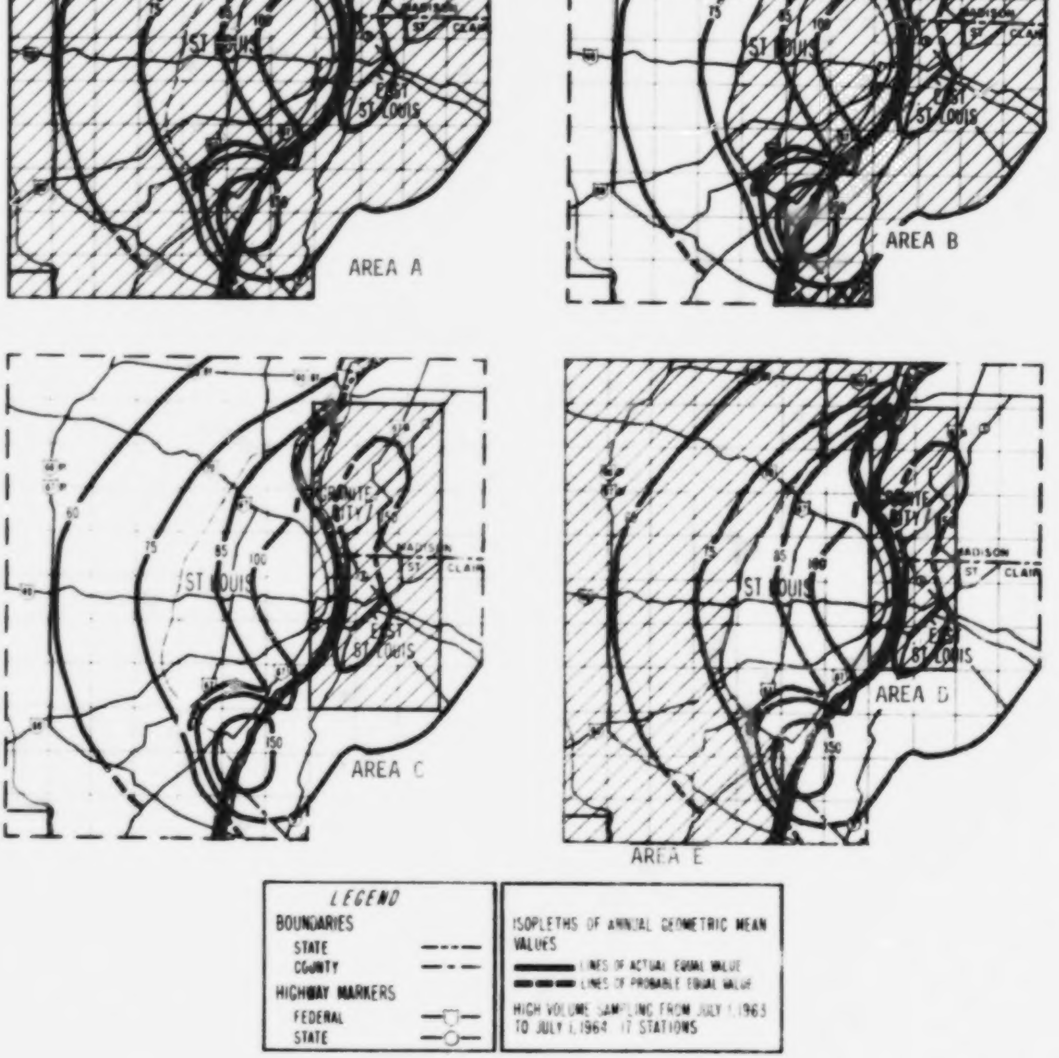

AREA A
AREA B
AREA C
AREA D
AREA E
ST LOUIS
EAST ST LOUIS
GRANITE CITY
MADISON
ST CLAIR
60
75
85
100
150
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
ISOPLETHS OF ANNUAL GEOMETRIC MEAN VALUES
LINES OF ACTUAL EQUAL VALUE
LINES OF PROBABLE EQUAL VALUE
HIGH VOLUME SAMPLING FROM JULY 1, 1963 TO JULY 1, 1964 17 STATIONS

Figure 6. Location maps of areas used in determining relationships between emission density and air quality.

Table 4. MEAN ANNUAL PARTICULATE LOADINGS AND CORRESPONDING PARTICULATE EMISSION DENSITY IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA

Area No.[a]	Land area, mi^2	Mean annual concentration, $\mu g/m^3$	Emission density, tons/mi^2
A	394	92	269
B	176	115	510
C	75	125	637
D	42	150	993
E	218	60	74

[a] Locations of areas are shown in Figure 6.

According to Figure 5, the limiting emission density corresponding to the desired annual geometric mean concentration of 75 micrograms per cubic meter is approximately 175 tons per square mile per year. To achieve the desired 75 micrograms per cubic meter, the average emission density of any contiguous area of considerable size (probably about 20 square miles or more) should be limited to 175 tons per square mile per year. The variation in emission density within these areas will undoubtedly result in a considerable variation in the ambient concentrations of suspended particulates within these areas.

The 175 tons per square mile is an average over an entire year; the rate at which the pollutant is emitted and meteorological parameters determine the ambient air concentration. For example, if the 175 tons per square mile were emitted during a 3-month period, the concentrations would be far different than if the emissions were spread over the entire year. Similarly, a constant emission over a 24-hour period would result in a much different concentration than if the same amount were emitted during an 8-hour period. In light of this, the following qualifying condition must be made for interpreting and applying the desired emission density of 175 tons per square mile per year. This emission density can be related to air-quality only if the hour-to-hour, day-to-day, and season-to-season emission variations remain approximately the same as they were during the sampling period on which the relationship curve is based. Any major changes in the distributional patterns of emissions during the year will undoubtedly displace the curve presented in Figure 5. Since, however, the distributional patterns of emissions are not expected to change drastically, the relationship expressed in Figure 5 can be used effectively.

Land Use and Allowable Emission Densities

The emissions of particulate matter are categorized according to the type of land use from which they originate. Such categorizing relates the emissions to the actual land areas from which they arise and allows the development and use of different allowable emission densities for each type of land use. The use of the same allowable emission density for all types of land use would be highly impractical and in the cases of industrial areas unattainable. Furthermore, the control of industrial emissions to the same degree as emissions in a residential area is not needed. The industrial areas are generally removed from populated areas even if only by several hundred yards, and the majority of emissions are discharged from elevated stacks. In contrast, the emissions from residential areas are discharged from much lower elevations and in most instances may be within a few feet of the point where effects may occur. Furthermore, the requirements for general air-quality in industrial areas are not as strict as in the areas where people live.

Four different land-use categories are considered: industrial, commercial, residential, and open space. The industrial land-use category includes the emissions generally arising from this type of land use and also open-burning dumps and municipal incinerators. The commercial land-use category, as used herein, besides including all the business districts, also includes the emissions from institutional facilities such as schools and hospitals. Residential land-use areas are considered as all of the present built-up residential areas and include the emissions from these areas. All land areas not included in the industrial, residential, or commercial categories were considered as open space and include roads, parks, cemeteries, and presently undeveloped or vacant land. The emissions from this category are emitted by transportation sources.

According to the previously established relationship between air quality and emission density, an allowable emission density of 175 tons per square mile per year will result in an air quality of approximately 75 micrograms per cubic meter. To be consistent with the average emission density of 175 tons per square mile per year, the allowable emission densities selected for each type of land use should yield this value overall, if considered in terms of land areas in each category. The selected allowable emission densities are presented in Table 5. The selection of these densities was based on the distributional patterns of the different land-uses and are expected to provide an average of 175 tons per square mile per year, not only for the entire area, but also for each political subdivision and most areas of more than 20 square miles.

Emission Reduction Plan

The existing and allowable emissions have been established previously. It is the purpose, through the development and use of an emission reduction plan, to determine what control regulations are needed to reduce the existing emissions to within allowable limits and yet allow for future growth. At the same time, it has been necessary to test the proposed regulations in terms of their feasibility and to suggest dates for compliance.

In a few instances the proposed regulations may not achieve the needed reductions in pollutant emissions. This may happen, for example, if a number of large pollution sources are located in a relatively small area. To insure that such

Table 5. ALLOWABLE AND EXISTING PARTICULATE EMISSION DENSITIES BY LAND USE IN ST. LOUIS - EAST ST. LOUIS CENTRAL URBANIZED AREA

Land use	Area, mi^2	Percent total	Existing emission density, $tons/mi^2/yr$	Allowable emission density, $tons/mi^2/yr$	Additional reduction needed, %
Industry	36	9.1	1,890	600	68.2
Residential	153	38.8	170	130	22.3
Commercial	23	5.8	255	175	31.6
Open space	182	46.3	35	100	0.0
Central urbanized area	394	100.0	269	175	39.8
					1/20 - CR

problems are solved, a proposal for individual consideration of the sources in these areas is included.

The discussion of the emission reduction plan is divided into four sections according to land-use categories. Since the proposed regulations in some cases apply to sources in more than one land-use category, a certain amount of duplication has been unavoidable.

Although the objective is to treat the central urbanized area as a whole, without regard to political subdivision boundaries, and to develop uniform control regulations for all areas, the applicability of the proposed regulations had to be tested on a smaller area basis. The four political subdivisions were selected as the basic areas for this purpose. The effects of the various control regulations in reducing the emission were tested by considering what the resultant emissions would be in each political subdivision. For a control regulation to be acceptable, the resultant emissions were required to be less than the allowable emission in each area.

Industrial Land Use - During 1963, an estimated 68,023 tons of particulates were released from the various sources located in this land-use category and resulted in an average density of approximately 1,890 tons per square mile per year. The primary sources of these emissions were the combustion of coal (57%), industrial processes (33%), and refuse disposal (9%). The existing emission densities ranged from approximately 1,060 tons per square mile per year in St. Louis County to over 2,800 tons per square mile in the urbanized portion of Madison County. All the existing emission densities are far above the estimated allowable emission density of 600 tons per square mile, and therefore particulate emissions must be reduced in all parts of the urbanized area.

To achieve the desired emission density of 600 tons per square mile per year as an average for the industrial land-use use portion of each of the political subdivisions, emissions from each of the primary sources must be reduced considerably. Programs for limiting emissions from the burning of coal, industrial processes, and refuse disposal must be implemented. The control regulations proposed herein are expected to reduce the emissions to the allowable limits.

Combustion of fuels - An estimated 38,500 tons of particulate matter from the combustion of coal was emitted in industrial areas during 1963. A reduction in coal combustion emissions to approximately 9,147 tons per year is needed. The 9,147 tons per year represents approximately 42 percent of the total allowable emission for the industrial land-use category. The remaining 58 percent would be emissions from industrial processes and refuse disposal.

Various control plans and approaches to reduce the emissions to within the allowable limits were investigated. The control plan presented in Figure 7 was chosen as the most applicable to achieve the desired emission reductions overall and in each of the political subdivisions. The control of particulate emissions according to curve No. 1 of Figure 7 is expected to reduce the emissions from the combustion of fuels from 39,224 tons per year to 9,871 tons per year, for an overall reduction of 75 percent. Calculated emissions after control on a plant-by-plant and boiler-by-boiler basis were based on estimated rated capacities of boilers to determine the allowable emission rates and on annual fuel consumption to determine the yearly emissions. The total annual emissions after reduction could thus be determined on the total area as well as on political subdivisions. The control equipment needed to achieve the emission limitations of curve No. 1 of Figure 7 varies from simple mechanical collectors (cyclones and multicyclones) with collection efficiencies of approximately 70 percent to electrostatic precipitators with efficiencies of 96 percent. According to the equipment sizes in use in the Study area, most pulverized-coal units and spreader stokers would require electrostatic precipitators, whereas most of the other stokers could be equipped with mechanical collectors.

An exception was made for spreader stokers. A separate emission limitation (curve No. 2 of Figure 7) permits the use of high-efficiency mechanical collectors on spreader stokers up to 500 million Btu per hour rated capacity. The main consideration in adopting this special limitation was the reported high cost of controlling a relatively small percentage of total combustion emissions. Because only about 20 of these units are in use at the present time, the net effect of this exception on the planned emissions will increase the planned emission by some 600 tons per year in the industrial land-use category and by much less in the commercial land-use category.

If spreader stokers continue to be installed in built-up urban areas, methods to control their emissions will have to be found so that limitations comparable to those placed on other types of equipment can also be achieved with spreader stokers. Appointment of an officially constituted technical committee is recommended to study controlling the emissions from spreader stokers by using curve No. 1 as a guide. Two years should be sufficient time for this study.

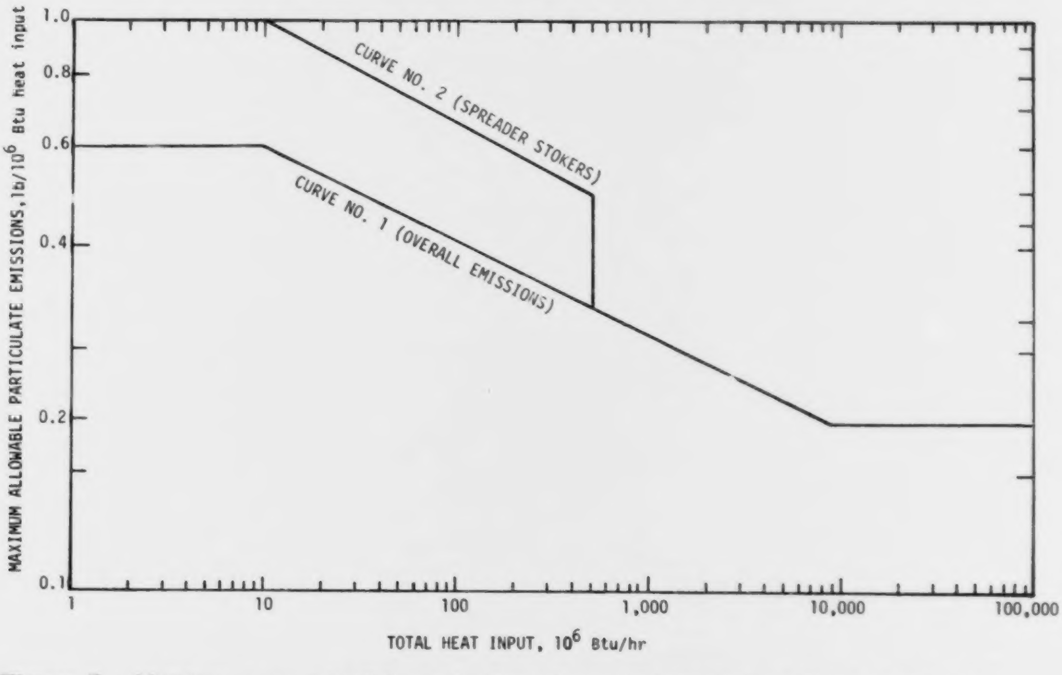


Figure 7. Maximum permissible emission of particulate matter from indirect-heating, fuel-burning installations in Interstate Air Pollution Study Area.

Industrial processes - Since particulate emissions from industrial processes contribute a considerable portion of total industrial emissions, reductions in process emissions are also necessary. During 1963, an estimated 22,673 tons of particulate matter was emitted to the air from the various industrial processes. To attain the desired emission densities for industrial land-use, a plan to reduce the existing process emissions to approximately 5,000 or 6,000 tons per year for the entire urbanized area is required. Emissions from industrial processes will then constitute approximately 25 percent of total industrial emissions.

Various means and approaches were investigated for providing reduction of process emissions. The emission limitation table based on process weight that was adopted in the San Francisco Bay Area (Table 6) was found to be a practical and adequate means of reaching the desired emission densities. The applicability of these emission limitations was tested to the extent possible by considering each plant and process individually. For each major manufacturing process for which production data were obtained by questionnaire, a process weight rate in tons of material per hour was computed and then translated into allowable emission rates by the use of Table 6. This procedure provided an estimate of the total process loss emissions in the community after control.

The adoption and full implementation of these emission limitations are expected to result in the reduction of process emissions from 22,673 tons annually to approximately 4,200, for an overall reduction of 81 percent. This is comparable to the 75 percent reduction needed for emissions from fuel-burning installations.

Essentially, these limitations require a reduction of emissions of about 80 percent for small operations and 95 percent or more for large operations. In a few isolated cases the controls needed according to the process weight table may be unduly strict if considered in terms of the total quantity of particulate matter emitted from the plant. In such instances, a variance may be granted if it can be shown that increases in emissions will not create nuisances or appreciably affect the emission reduction plan. Whenever variances are granted, other emissions must be more stringently controlled and limitations placed on future expansion in the area.

An alternative method for determining the allowable emissions from individual processes would be on the basis of potential or uncontrolled emissions. This method would require that each manufacturer provide data on the quantity of material that would be emitted if no controls were employed. Such a method would eliminate the two primary objections to the use of the process-weight table. The use of the process-weight table is predicated on the assumption that the quantity of material used and not the type of material or process determines the quantity of material emitted. This, however, is not entirely true. For a given process-weight rate, the uncontrolled emissions may vary considerably. The other objection to the use of the process-weight table in determining an allowable emission rate is the necessity for industries to divulge process data that are considered proprietary. Both of these shortcomings would be overcome if a potential emission instead of process-weight scale were used.

Industries should therefore be encouraged to develop capability in assessing the types and quantities of pollutants emitted; and when data on potential emissions become available, emission limitations could be prescribed on a potential emission

Table 6. ALLOWABLE RATE OF EMISSION BASED ON PROCESS WEIGHT RATE[a]

Process weight rate,		Rate of emission, lb/hr	Process weight rate		Rate of emission, lb/hr
lb/hr	tons/hr		lb/hr	tons/hr	
100	0.05	0.551	16,000	8	16.5
200	0.10	0.877	18,000	9	17.9
400	0.20	1.40	20,000	10	19.2
600	0.30	1.83	30,000	15	25.2
800	0.40	2.22	40,000	20	30.5
1,000	0.50	2.58	50,000	25	35.4
1,500	0.75	3.38	60,000	30	40.0
2,000	1.00	4.10	70,000	35	41.3
2,500	1.25	4.76	80,000	40	42.5
3,000	1.50	5.38	90,000	45	43.6
3,500	1.75	5.96	100,000	50	44.6
4,000	2.00	6.52	120,000	60	46.3
5,000	2.50	7.58	140,000	70	47.8
6,000	3.00	8.56	160,000	80	49.0
7,000	3.50	9.49	200,000	100	51.2
8,000	4.00	10.4	1,000,000	500	69.0
9,000	4.50	11.2	2,000,000	1,000	77.6
10,000	5.00	12.0	6,000,000	3,000	92.7
12,000	6.00	13.6			

[a] Interpolation of the data in this table for process weight rates up to 60,000 lb/hr shall be accomplished by use of the equation $E = 4.10\ P^{0.67}$, and interpolation and extrapolation of the data for process weight rates in excess of 60,000 lb/hr shall be accomplished by use of the equation

$E = 55.0\ P^{0.11} - 40$, where E = rate of emission in lb/hr and

P = process weight rate in tons/hr.

scale. Until such time, however, the use of the process-weight scale is the most practical method of regulating the emissions from the many different processes employed in the area. Whenever potential emission data become available, a better understanding of the hour-to-hour and day-to-day variations in emission rates will ensue. It is, therefore, reasonable to expect that frequency distributions of emissions similar to the ones used for air-quality will be formulated and emission limitations based on maximum as well as average emissions will be prescribed. In this manner a closer control on the actual emissions, and thus the daily or even hourly concentrations, can be achieved. Relating such emissions to the actual land area a source occupies, and setting emission limitations on the basis of areas and land-use mix rather than process-weight or volume of stack gases seems to be the best method for insuring desired air-quality in all areas as well as the most equitable means for apportioning the total allowable emissions to individual sources.

Refuse disposal - An estimated 6,200 tons of particulates is emitted annually from the burning of refuse material in industrial areas. Included in this total are the estimated emissions from all of the open-burning dumps and the municipal incinerators. Although only a portion of the waste burned in these dumps and incinerators originates with the area's industries, the general location of these dumps in the industrial land-use areas necessitates their inclusion in the industrial land-use category.

Besides emitting some 5,000 tons of particulates per year, open-burning dumps precipitate complaints about smoke, reduced visibility, odors, and general unsanitary practices. Regulations prohibiting open-burning in dumps have been enacted in all of the political jurisdictions included in the urbanized portion of the Study area. To eliminate this source of air pollution, regulations prohibiting open-burning must be strictly enforced.

The municipal incinerators presently emit approximately 1,000 tons of particulates per year. If these emissions were controlled to the recommended rate of 0.2 grain per standard cubic foot, the annual particualte emissions would be reduced to approximately 670 tons per year. If all refuse material presently being burned openly in all land-use categories were to be burned in municipal incinerators, total particulate emissions from refuse burning would decrease from approximately 15,000 to 3,000 tons annually.

Relatively small quantities of refuse material are being disposed of by industrial incineration. Particulate emissions from this operation during 1963 were estimated to be only 200 tons. The recommendations made relating to domestic incinerators should be extended to include all incinerators. Such regulations should require that all incinerators be of the multiple-chamber design and that the emissions be limited to 0.2 or 0.3 grain per standard cubic foot, depending on size.

Implementation of the recommended regulations concerning the refuse disposal is expected to reduce the refuse-disposal emissions in the industrial areas from the presently estimated 6,200 to approximately 2,700 tons per year.

Summary - Implementation of the recommended emission limitations on the sources of pollution included in the industrial land-use category is expected to reduce the emissions of particulates from the present total of 68,023 tons per year to approximately 16,760 tons per year. The resulting emission of 16,760 tons per year is within the allowable emission for the entire area and only slightly exceeded in one of the political subdivisions (Table 7). A breakdown of industrial emissions by source category, showing both the existing and reduced emissions, is presented in Table 8.

Residential Land Use - Annually, 25,540 tons of particulates is emitted in the residential portions of the Study area. The primary sources are the combustion of coal for space heating and the open-burning of refuse material. In areas where these practices are common, the proposed allowable emission density of 130 tons per square mile per year is exceeded by as much as a factor of 5. The average emission density from the residential areas is approximately 170 tons per square mile, but is as high as 450 tons per square mile in the City of St. Louis. Of the 450 tons per square mile, 75 percent, or an equivalent of 388 tons per square mile, is caused by the burning of coal and 21 percent by the open-burning of refuse.

Table 7. EXISTING, ALLOWABLE, AND PLANNED EMISSIONS OF PARTICULATES IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA

Subdivision	Land-use category	Land area, mi^2	Particulate emissions, tons/yr		
			Existing	Allowable	Planned[a]
City of St. Louis	Industrial	9.9	14,450	5,940	4,220
	Residential	21.6	9,690	2,810	1,970[b]
	Commercial	3.9	3,690	680	700[c]
	Open space	25.6	2,750	2,560	2,750
	Total	61.0	30,580	11,990	9,640
St. Louis County[d]	Industrial	8.0	8,490	4,800	1,660
	Residential	91.0	4,750	11,830	600[b]
	Commercial	11.8	980	2,065	2,050[c]
	Open space	107.6	1,820	10,760	1,820
	Total	218.4	16,040	29,455	6,130
Madison County[d]	Industrial	8.4	23,887	5,040	5,805[e]
	Residential	19.0	4,960	2,470	540[b]
	Commercial	3.3	500	578	580[c]
	Open space	23.3	650	2,330	650
	Total	54.0	29,995	10,418	7,575
St. Clair County[d]	Industrial	9.7	21,199	5,820	3,575
	Residential	21.0	6,140	2,730	1,570[b]
	Commercial	3.7	640	650	640[c]
	Open space	26.2	1,240	2,620	1,240
	Total	60.6	29,218	11,820	8,405
Central urbanized area	Industrial	36.0	68,023	21,600	16,760[f]
	Residential	152.6	25,540	19,840	4,680[b]
	Commercial	22.7	5,810	3,973	3,970[c]
	Open space	182.7	6,460	18,270	6,460
	Total	394.0	105,837	63,683	31,870

[a] Emissions from existing installations after reduction.

[b] Estimated 1975 emissions based on complete elimination of open burning and natural decline in use of coal as heating fuel.

[c] Arbitrary estimate.

[d] Data are from only the portion of the study area included with the 394-square-mile central urbanized area of principal interest in the Study.

[e] Includes 5,200 tons per year from The Venice Power Plant.

[f] Includes a projected emission of 1,500 tons as a result of increased incineration of waste (not included in subtotals).

Table 8. INDUSTRIAL PARTICULATE EMISSIONS IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA

	Existing emissions, tons/yr	After reduction emissions, tons/yr
Fuel use	39,224	9,871
Coal	38,500	9,147
Fuel oil	406	406
Gas	318	318
Process emissions	22,673	4,196
Coffee processing	38	34
Sulfuric acid	192	192
Asphaltic concrete	198	128
Steel foundries	517	295
Gray iron foundries	437	140
Non ferrous foundries	38	38
Steel mills	9,159	2,056
Superphosphate mfg.	223	60
Coke plants	73	73
Cement plants	3,630	360
Grain industry	6,695	670[a]
Other reported sources	1,473	150[a]
Refuse disposal	6,126	2,700
Municipal incineration	1,004	2,700
Industrial incineration	193	2,700
Open burning dumps	4,929	0
Totals	68,023	16,767

[a] Assumed additional 90 percent efficiency.

These data indicate that to achieve the desired emission density, emissions from these two source categories must be reduced.

Combustion of coal - Emissions from a domestic space-heating unit burning coal are equivalent to emissions from over 100 comparable units using gas or 30 units burning fuel oil. In effect, one coal-burning unit requires as much air space as 100 units heating with gas.

The use of coal for domestic needs has declined rapidly during the past 20 years (Figure 8), and emissions have been reduced accordingly. If the present trend continues, by 1975 the emissions from the burning of coal will reach an average density of approximately 100 tons per square mile in the City of St. Louis and less overall. This would be within acceptable limits.

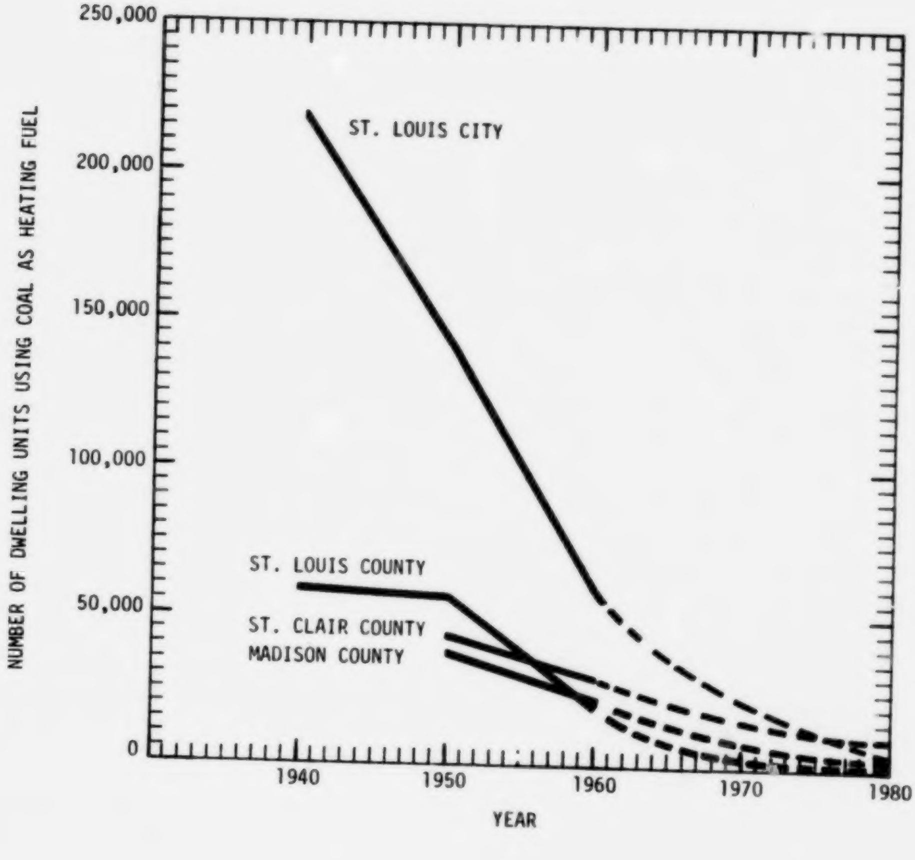


Figure 8. Domestic-heating use of coal in Interstate Study Area.

Some of the 50,000 coal-heated dwelling units in the urbanized area are equipped with hand-fired units. In addition to contributing inordinate amounts of particulates to the atmosphere, these units cause excessive smoke and odors. Operating hand-fired units without creating excessive smoke emissions is practically impossible. Elimination of these units would eliminate the smoke and odor nuisances and accelerate the natural decline in the use of coal. The incurred costs of converting to the use of gas- or oil-fired central heating would be approximately $550 for gas and $650 for fuel oil. To convert from coal hand-fired room heaters to gas units would be about $100. Heating with gas instead of coal would be $23 per year cheaper. Heating with fuel oil would cost only about $10 per year per dwelling more. Heating with gas or oil is more convenient and cleaner, and provides much better temperature control than heating with coal. Elimination of hand-fired units is recommended and should be carried out on a progressive and equitable basis over a period of approximately 3 years. Each air pollution control agency should devise a schedule so that one-third of all units are converted each year. This could be done by delineating zones to the severity of the problem.

Open burning of refuse - The open burning of refuse is prevalent in all parts of the urbanized area. Besides emitting almost 7,000 tons of particulates annually, open burning releases excessive smoke, hydrocarbons, odors, and undoubtedly creates a fire hazard. The burning of leaves, not included in the above estimate, adds a considerable quantity of particulates to this total.

The cities of St. Louis and East St. Louis presently have regulations prohibiting open burning of refuse. Such regulations should be adopted throughout the entire metropolitan area. To assure compliance with these regulations, a strict enforcement program is required. The collection of refuse from the outlying sparsely populated areas would create enforcement and collection problems greater than anticipated air pollution problems and would be expensive; therefore outlying areas of less than 100 dwelling units per square mile should be exempted from open-burning restrictions. To provide a workable basis for enforcement of this type program, each air pollution control agency should designate the boundaries by streets and roads of areas in which open-burning is prohibited.

Incineration of refuse - The severity of smoke, odor, and particulate matter emitted during the incineration of refuse varies considerably and depends primarily on the design and operation of the incinerator. Stack tests have shown that the emissions of particulate matter associated with incinerators of multiple-chamber design are 4 to 10 times less than those from the single-chamber type. To reduce the particulate emissions in the community and minimize excessive smoke and odors, it is recommended that only incinerators of multiple-chamber design or of an equally effective design be allowed. This provision will require that the single-chamber incinerators in use at present be eliminated or converted to multiple-chamber type. Five years should provide ample time for a complete changeover.

To insure that the incinerators are properly designed, built, and operated, an additional requirement limiting the emissions of particulate matter to 0.3 grain per standard cubic foot for installations burning less than 200 pounds per hour and 0.2 grain per standard cubic foot for others should be included. A properly designed and operated multiple-chamber incinerator in this size range can meet these limitations without additional air pollution control devices.

Burning of Leaves - Although quantitative data are not available, the burning of leaves during the fall months releases large quantities of particulates to the air, causes excessive smoke that results in a drastic reduction in visibility, and is a potential fire hazard. Until facilities for collecting and handling this refuse are available, burning of leaves should be permitted only between 10 a.m. and 4 p.m. when the atmospheric dilution capacity is the greatest.

A period of 5 years seems to be reasonable for developing a collection and disposal capability that will accommodate all forms of domestic refuse. The above recommended restrictions on domestic refuse disposal, while reducing the emissions of particulates by more than 7,000 tons per year, will create a demand for extending the collection coverage and for additional municipal refuse disposal facilities.

Summary - An estimated 25,500 tons of particulates is discharged annually from residential land-use areas. The elimination of all hand-fired units will reduce this total; however, because of the lack of data concerning the number of these units in use, a quantitative estimate cannot be made. The natural decline in the domestic use of coal is expected to reduce particulate emissions. Assuming that half of the coal-burning units are converted to gas and the other half to distillate fuel oil, the net reduction would be 10,800 tons per year by 1970 and 13,800 tons per year by 1975.

The elimination of all open-burning of refuse is expected to decrease the particulate emissions by some 6,940 tons per year. Since this quantity of refuse is expected to be disposed of in municipal incinerators, the 6,940 tons per year may be taken as the net reduction in the residential areas.

The overall reduction in particulate emissions of 17,700 tons per year by the year 1970 can be expected if the above recommendations are implemented and if the present trend away from the use of coal for heating residences continues. In the City of St. Louis, where the residential emission density is presently the highest at 450 tons per square mile per year, these actions would result in an estimated emission density of 145 tons per year by 1970 and slightly less than 100 tons per square mile per year by 1975. These estimates were based on the premise that the existing residential land-use areas are already fully developed and occupied. Increases in the population of the urbanized area can, therefore, occur only in the areas presently labeled as open space, and estimates of additional pollution sources in the existing residential land-use areas need not be made.

Commercial Land-Use - During 1963 the emissions of particulate matter from commercial land-use areas amounted to 5,800 tons, 95 percent of which was from the combustion of coal. Because the emissions were from relatively small land areas, the resultant emission densities exceed the allowable by a considerable amount. To achieve the desired emission limits, a reduction in emissions from the combustion of coal is also needed in this category.

Elimination of all hand-fired furnaces is also recommended for commercial establishments. Although only a small number are in use, their elimination will tend to reduce the numerous nuisance complaints arising from excessive smoke. Because of the similarities among commercial, institutional, and industrial firing equipment used, the same emission limitations (Figure 8) can be applied to these installations. The lack of data concerning the types and sizes of the units in use does not allow an estimate of the quantities of particulates that would be emitted after compliance with the regulations. It is expected, however, that the reductions in emissions will be sufficient to reach the desired emission densities. Recommendations concerning the control of emissions from refuse disposal made previously for domestic and industrial units should also cover all commercial on-site incineration and open-burning.

Open Space - As previously noted, open space includes roads, parks, cemeteries, vacant land, lakes, and rivers. The only emissions arising from these areas are from automobiles, trucks, buses, locomotives, and ships. During 1963 an estimated 6,460 tons of particulates was emitted from these pollutant sources. Assuming that 24 percent of the St. Louis urbanized land area is taken up by roads, railway rights-of-way, and surface waters, the existing emission density would be approximately 70 tons per square mile per year, which is within the preselected allowable density of 100 tons per square mile per year.

Impact of Proposed Regulations on Existing and New Emissions

The existing, allowable, and planned particulate emissions summarized in Table 7 show that the emission reduction plan provides for sufficient reductions for the urbanized area as a whole as well as for each political subdivision. Furthermore, sufficient reductions are also achieved for each of the land-use categories except for the industrial land-use category in Madison County, which is a special case to be discussed in the next section. The difference between the allowable and planned emissions in Table 7 is the quantity of particulate matter that can be added to the air without exceeding the desired emission density. An allowance of approximately 20 percent of the planned emissions is provided for the City of St. Louis and Counties of St. Clair and Madison. The large difference observed for the St. Louis County portion of the urbanized area allows for a considerable expansion, provided that a proper distribution of sources is achieved.

Increases in pollutant emissions in the industrial category, for instance, may result from expansion of existing plants or addition of new plants on the industrial land-use areas. An allowance for this expansion is included by providing the planned emissions of lower magnitude than the allowable.

The development of new lands in the open-space category for industrial, commercial, or residential purposes would increase the allowable emissions for these categories and provide for less allowable emissions in the open-space category. This is the primary reason for including an allowance of 100 tons per square mile per year for the open-space category. Since little pollution will emanate from open-space, the allowable emission density for certain areas is in reality higher than 100 tons per square mile.

The effect that the proposed reductions in emissions would have on air-quality in certain presently heavily polluted areas can be surmized from Figure 9. The frequency distributions of concentrations recorded at one sampling station in each of the three political subdivisions, City of St. Louis, Madison County, and St. Clair County, were plotted and then reduced by the percent reduction in emissions expected to result from complete compliance with the proposed regulations. According to Figure 9 the City of St. Louis requires a reduction of 54 percent; Madison county, 77 percent; and St. Clair County, 67 percent. In all three cases a close agreement between the air-quality goal and "resulting planned concentrations" has been projected. The technique employed in formulating Figure 9 has been used in other areas to calculate the reductions in emissions needed to meet the air-quality goal. The reductions indicated in Figure 9 are in general agreement with reductions determined by the methods used in developing the particulate air-use plan for the St. Louis Study area. According to results determined by methods used in developing the air-use plan, the City of St. Louis requires a reduction of 68 percent; Madison County, 75 percent; and St. Clair County, 71 percent.

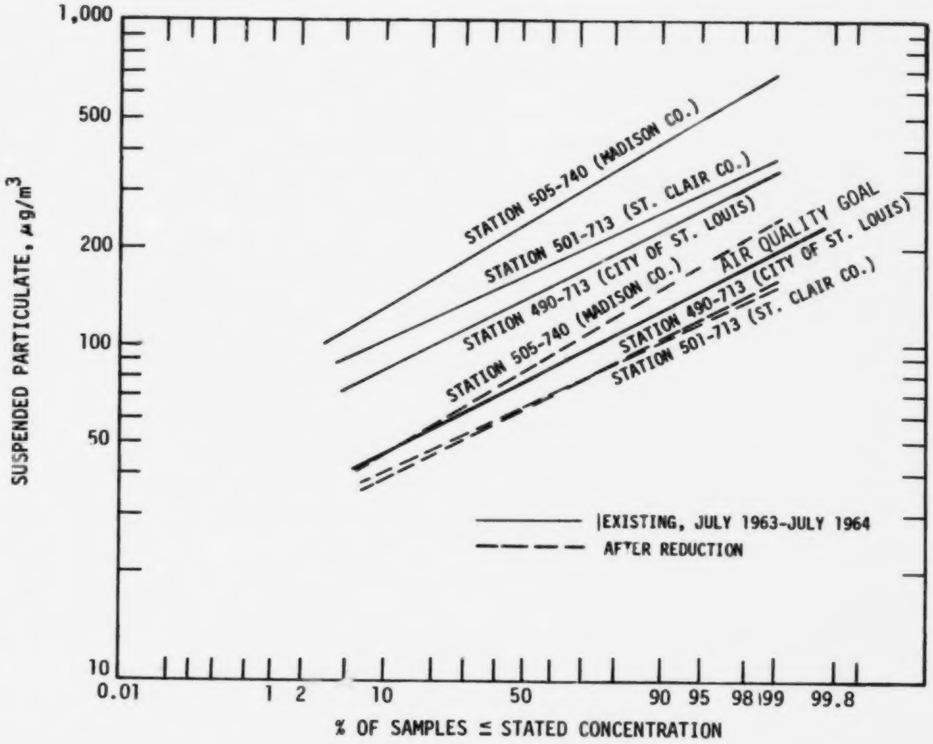


Figure 9. Existing and projected 24-hour suspended particulate frequency distribution.

Special Applications of Emission Reduction Plan

As indicated previously, implementation of the reduction plan is expected to reduce emissions to the allowable levels for land-use categories and political subdivisions. Because of the presence of an extremely large source of pollution or a complex of sources in a small area, the resulting emissions may not be within the acceptable limits in the immediate area. In such situations, more stringent regulations than those previously proposed may be needed to achieve the desired air-quality. To assure that such problem areas are given the needed consideration, such areas should be considered individually.

As a guide to locating such areas, the following recommendations are made. Any 2-mile-diameter area from which the emissions of particulates, after the implementation of the suggested controls, are greater than 2,000 tons per year should be considered as a potential problem area. The emissions from all major sources in these areas should then be investigated and the expected air-quality determined by the use of diffusion equations, with suitable allowance for factors such as expected life of sources and cost of additional controls. If the investigation reveals that the air-quality goals will not be met, additional control should be prescribed. Such an evaluation should also be made for any proposed pollution source in these particular areas.

A typical example is the area including the Venice Power Plant. The emissions of particulates from the Venice Power Plant, even after controlled to the limits specified in Figure 7, would be approximately 5,000 tons per year. Preliminary diffusion calculations show that the emissions from this source could add as much as 100 micrograms per cubic meter in the downwind direction to the particulate loading from the other sources in the area (see calculations in Appendix A.). In light of the air-quality goal of 200 micrograms per cubic meter as the 99 percentile value, the emissions from this source could be using about half of the dilution capacity of the air space within 2 or 3 miles and therefore should be further reduced. The controls specified by Figure 7 necessitate control equipment of approximately 96 percent efficiency; but an additional 2,500 tons of particulate could be removed by equipment with an efficiency of 98 percent. Before additional controls are prescribed for the plant, a cost evaluation should be made and the expected life of this source should be determined.

The control of emissions above those previously specified from this and any other source or sources falling into this category should be investigated jointly by the source operators and the respective air pollution control agency in an effort to determine the manner in which the requirements of the air-use plan and clean air may best be achieved.

AIR-USE PLAN - SULFUR DIOXIDE

Sulfur dioxide is emitted primarily during the burning of sulfur-bearing fuels and the manufacture of sulfuric acid. The two basic approaches to reducing the emissions of sulfur dioxide from the burning of fuels are the removal of sulfur compounds from the exit gases and the use of fuels with lower sulfur contents. The emissions from sulfuric acid production may be reduced either by the removal of sulfur dioxide from the exit gases or through the improvement of the conversion efficiency of sulfur dioxide to useful products. Methods for cleaning discharge gases have recently been developed, and equipment is nearing the final stages of development. The use of lower sulfur fuels can, however, be implemented sooner.

Air-Quality Goals

The recommended air-quality goals for sulfur oxides (measured as sulfur dioxide) in the Study area are based on effects. These goals specify that the annual arithmetic mean concentration should not exceed 0.02 ppm and that the concentration of 0.1 ppm should not be exceeded on more than 1 percent of the days in any consecutive 100-day period. These goals, based on the West-Gaeke method (or other method giving comparable results) of analysis and a 24-hour sampling period, should apply to any place where people live or where undesirable effects could occur if the specified concentrations are exceeded. For a complete discussion of air-quality goals and related criteria, see Volume VI of this report.

Design Period

Since the air-quality goal at the 99 percentile is defined in terms of 100 consecutive days, the reduction plan should be based on the season when sulfur dioxide concentrations are highest. The application of the emission reduction plan throughout the year would then result in approximating the desired air-quality during the worst season and provide lower pollutant concentrations during the other seasons. An alternative to this scheme would be to develop different emission limitations for each of the seasons. The approach used here is to design an emission reduction plan for the worst conditions and to approximate the degree to which these emission limitations could be relaxed during the other seasons.

Although sulfur dioxide concentrations were recorded only during the 3 winter months, certain inferences as to seasonal variation in sulfur dioxide concentrations may be made by considering the seasonal variation of the sulfation rates, the amount of emissions, and the atmospheric dilution capacity. During the winter season, the emissions of sulfur oxides are the maximum (140% of the annual average), and the measured sulfation rate is highest (150% of the annual average). The meteorological conditions during the fall and winter seasons are generally more conducive to higher concentrations than during other times of the year. The emissions during the heating season (winter) are increased primarily from the residential and commercial sources, which because of their relatively low heights of release have a more pronounced effect on ambient air concentrations. The winter season was, therefore, selected as the design period.

The degree by which the proposed emission limitations could be relaxed during other seasons can be inferred from the seasonal variation in emissions and sulfation rates. Assuming that the seasonal variation in emissions results in comparable variation of sulfur dioxide concentrations in the ambient air, the degree by which the emission limitations may be relaxed during the other seasons may then be calculated. Considering that the diffusion capacity is generally greater during the other seasons, with the possible exception of fall, and that the emissions during the non-heating season are primarily from industrial sources that discharge at much higher elevations, these calculations would be on the conservative side. Furthermore, the validity of this assumption, at least qualitatively, is supported by the observed seasonal relationship between the sulfation rate and emissions. The mean sulfation rate for the winter season is 150 percent of the annual and for the summer months is 74 percent of the annual. The corresponding percent distribution of emissions are 140 percent for the winter season and 75 percent for the summer.

Using the seasonal variation in emission rates alone as the basis, the emission limitations designed for the winter months could be reduced by factors of 1.6 for spring and fall, and 2.0 for summer. For a more workable plan, the time period for "winter" emission limitations may be extended to also include October, November, and March. During the remaining 6 months the emissions could be doubled.

Relationship of Air-Quality Goals to Design Period Concentrations

To allow the use of average concentrations and emission rates in subsequent calculations relative to the design period, it is necessary to express the 99 percentile air-quality goal in terms of a mean concentration. On the basis of the observed frequency distribution of 24-hour sulfur dioxide concentrations (for the period December 1964 through February 1965) at 21 centrally located sampling sites, a log-normal frequency distribution curve corresponding to 0.1 ppm at the 99 percentile and parallel to the average observed distributions was constructed (Figure 10). By this means a seasonal geometric mean concentration of 0.023 ppm

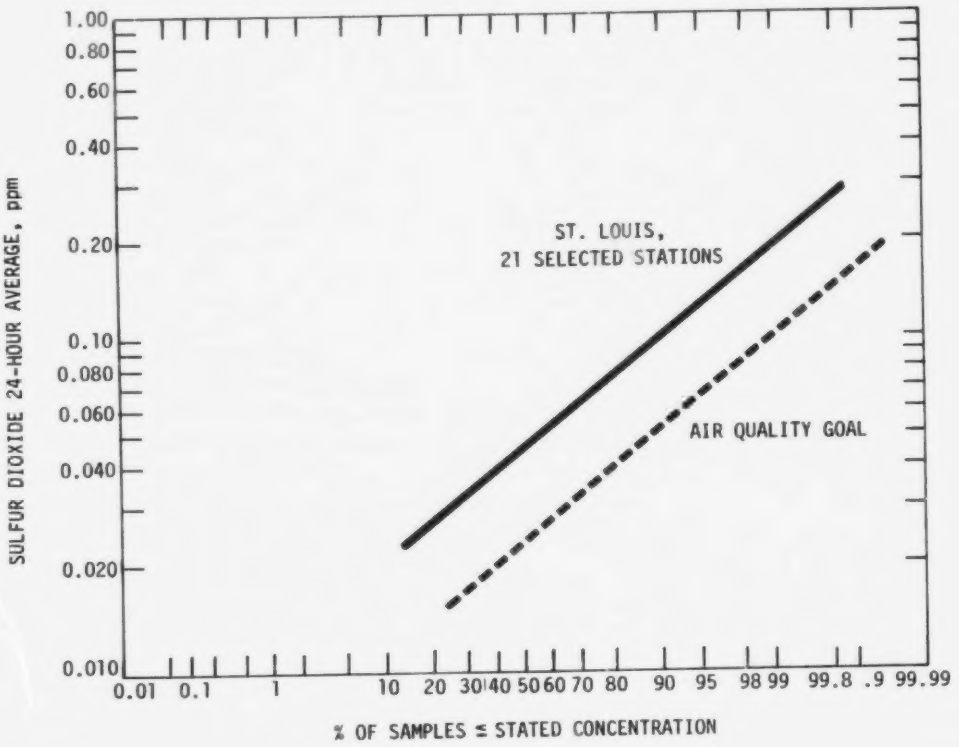


Figure 10. Geometric mean values of 24-hour sulfur dioxide frequency distribution - Dec. 1964 - Feb. 1965.

was obtained. This concentration is in keeping with the presently observed ratios of concentration at the 50 and 99 percentile points of the distribution.

As indicated earlier, the annual mean goal recommended for the Study area has been set at 0.02 ppm and relates to effects based on normal distribution of data. It is well to differentiate between this goal and the seasonal value of 0.023 ppm, geometric mean concentration, as related to a log-normal distribution. On the basis of a standard geometric deviation of 2.0, calculated from the observed distribution of data, the seasonal geometric mean concentration would be equivalent to an arithmetic seasonal mean concentration of 0.028 ppm. On the basis of the highest season, therefore, the goal for the annual arithmetic mean concentration is exceeded. The seasonal geometric mean of 0.023 ppm, however, relates to the 99 percentile goal of 0.1 ppm in a statistical sense only and does not directly relate to the emission reduction program design. It is therefore a secondary rather than a primary goal.

Although the emission limitations are to be relaxed during the nonheating season, other factors such as elevated release points, improved meteorological conditions, and lack of low-level emissions from space-heating operations should result in lower atmospheric concentrations of sulfur dioxide during this period as compared with the heating season. These lower concentrations during the nonheating season should in turn aid in the attainment of both the 99 percentile goal of 0.1 ppm and the annual arithmetic mean goal of 0.02 ppm in most portions of the Study area. Although both air-quality goals are expected to be achieved by implementing the emission reduction plan, 24-hour sulfur dioxide concentrations for other than the winter months should be measured both before and after the various portions of the emission reduction plan are implemented. This will permit an evaluation of the seasonal variations of ambient sulfur dioxide concentrations as well as the effect of the emission reductions on these concentrations.

Existing Concentrations

Sulfur dioxide was measured at 20 locations during the period December 1963, and January and February 1964 and at 40 locations during December 1964, and January and February 1965. The data collected during the winter of 1964-1965 were selected as the basis for the reduction plan. The more complete coverage of the area and the higher concentrations recorded during this time period influenced the selection. The differences observed during the two sampling periods are discussed in Volume III of this report.

The geometric mean concentrations recorded at the 40 sampling sites during the winter of 1964-1965 ranged from 0.015 ppm to 0.097 ppm. The geometric mean concentration for the area shown in Figure 2 weighted according to land areas was approximately 0.034 ppm. Figures 11 and 12 show the isopleths of the geometric mean and the 99 percentile concentrations, respectively. As evidenced from the isopleths in Figure 12, the air-quality goal of 0.1 ppm was exceeded at all of the sampling sites.

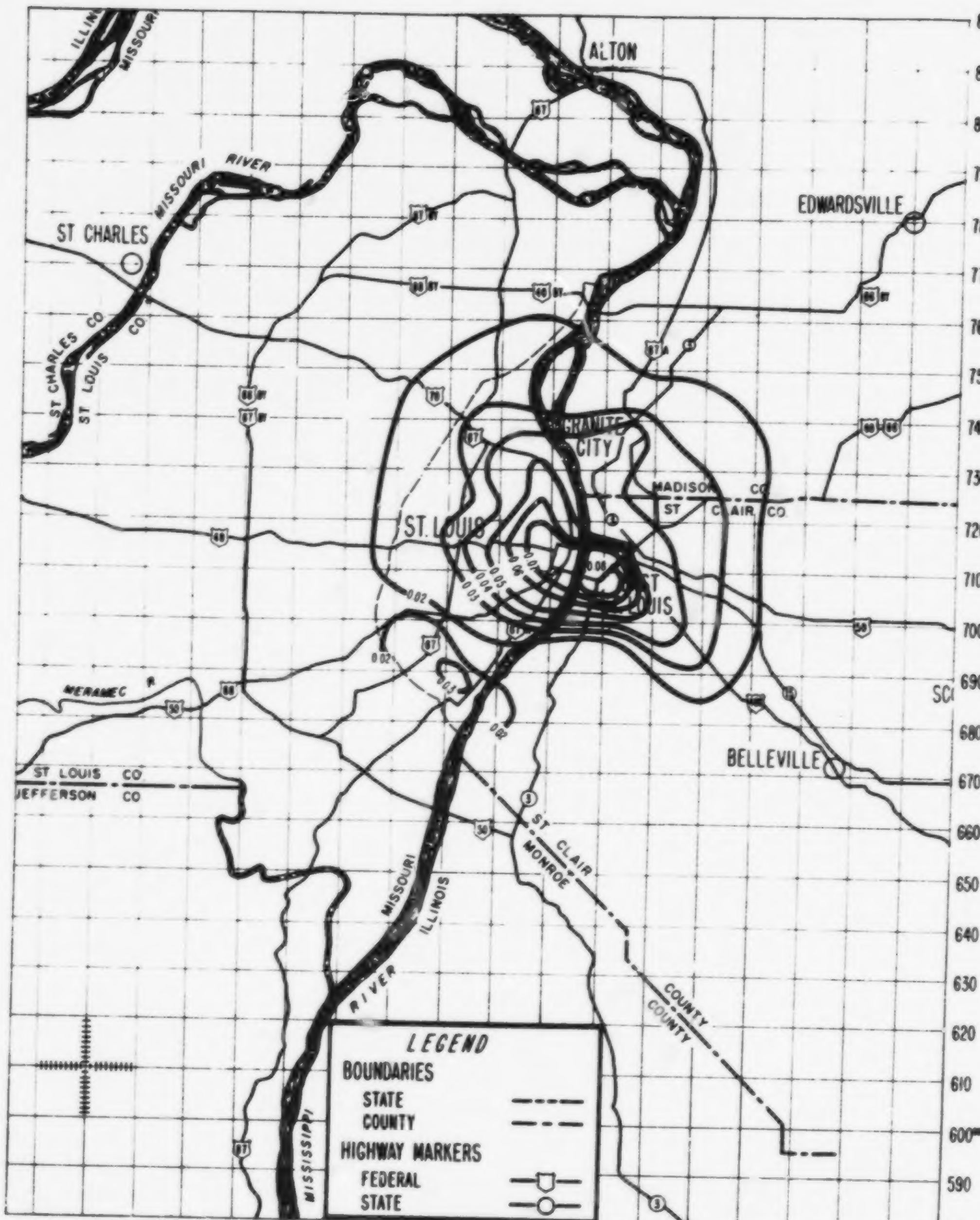

ALTON
EDWARDSVILLE
ST CHARLES
MISSOURI RIVER
ST CHARLES CO
ST LOUIS CO
GRANITE CITY
MADISON CO
ST CLAIR CO
ST. LOUIS
E. ST. LOUIS
BELLEVILLE
MERAMEC R
ST LOUIS CO
JEFFERSON CO
ST CLAIR COUNTY
MONROE COUNTY
MISSOURI
ILLINOIS
MISSISSIPPI RIVER
0.02
0.03
0.04
0.05
0.06
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
640
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800
810
820

Figure 11. Sulfur dioxide geometric mean values for 24-hour samples from 1964-1965 winter season (ppm).

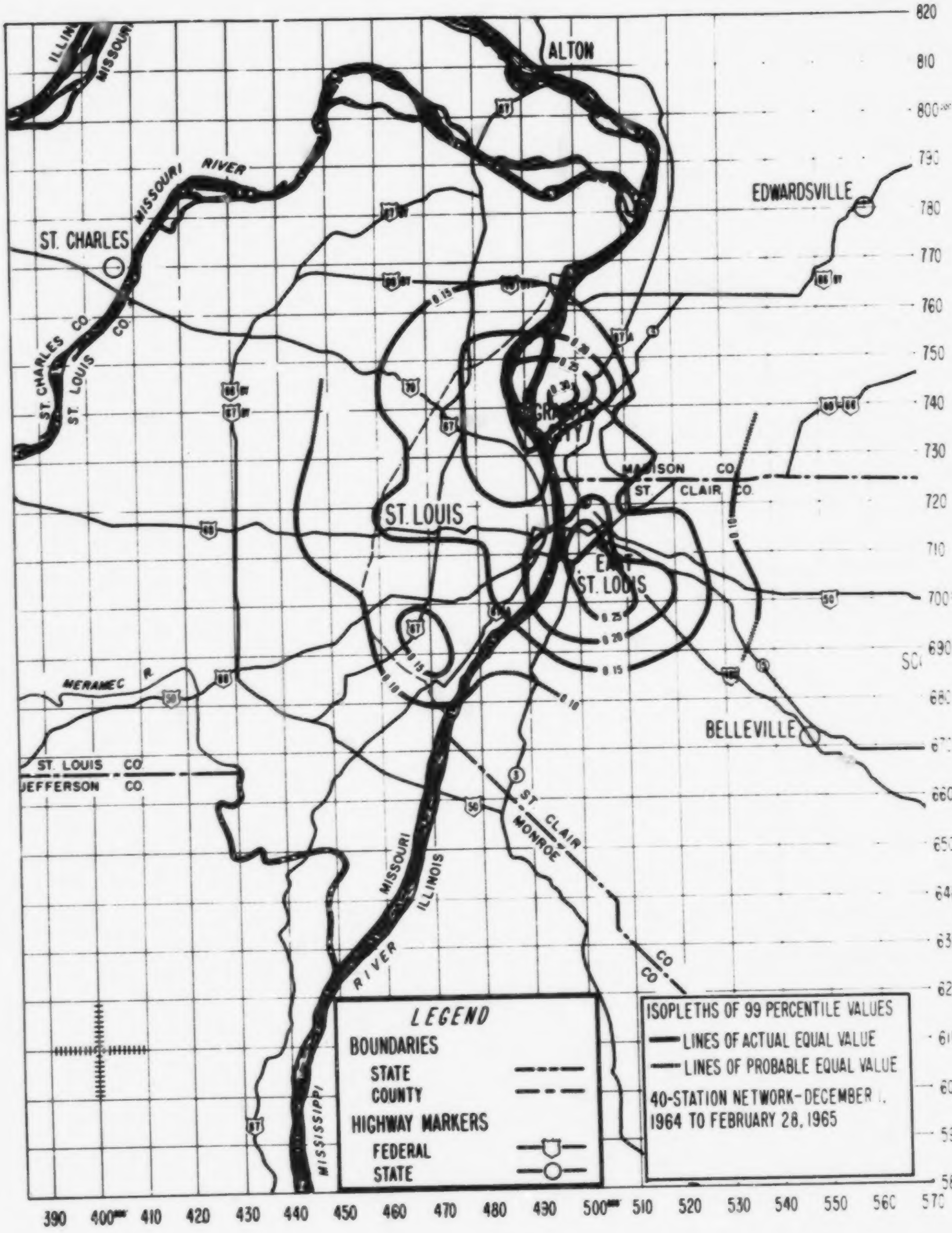

ALTON
EDWARDSVILLE
ST. CHARLES
MISSOURI RIVER
ST. CHARLES CO.
ST. LOUIS CO.
GRANITE CITY
MADISON CO.
ST. CLAIR CO.
ST. LOUIS
EAST ST. LOUIS
BELLEVILLE
MERAMEC R.
ST. LOUIS CO.
JEFFERSON CO.
ST. CLAIR CO.
MONROE CO.
MISSOURI
ILLINOIS
MISSISSIPPI RIVER
0.10
0.15
0.20
0.25
0.30
LEGEND
BOUNDARIES
STATE
COUNTY
HIGHWAY MARKERS
FEDERAL
STATE
ISOPLETHS OF 99 PERCENTILE VALUES
LINES OF ACTUAL EQUAL VALUE
LINES OF PROBABLE EQUAL VALUE
40-STATION NETWORK-DECEMBER 1, 1964 TO FEBRUARY 28, 1965
820
810
800
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570

Figure 12. Sulfur dioxide 99 percentile values for 24-hour samples 1964-1965 winter season (ppm).

Existing Emissions

Approximately 455,500 tons of sulfur oxides is released annually from the various pollutant sources in the Study area. A breakdown of these emissions by source category is given in Table 9. The primary source of sulfur oxides pollution is the combustion of sulfur-bearing fuels. More than 92 percent of the total emissions may be attributed to this source category. The combustion of coal, the primary producer of sulfur oxides, accounts for 403,000 tons of the emissions. The burning of distillate and residual fuel oil contributes 18,000 tons annually. The combustion of gas is insignificant as a source of sulfur oxides pollution. The annual quantities and the sulfur contents of the fuels burned in the Study area are summarized in Table 10. The listed values represent the average for each type and grade of fuel.

The 455,500 tons of sulfur oxides emissions comes from sources located in an area of some 3,500 square miles. If the emissions were distributed evenly throughout this area, the resulting concentrations would undoubtedly be within acceptable limits. This, however, is not the case. Some 250,000 tons of emissions is released in approximately 400 square miles of the highly urbanized portion of the Study area. The emissions from sources located in this urbanized portion (see Figure 2) are summarized in Table 11. Of the remaining sulfur oxides emissions, an estimated 137,000 tons is discharged from the Meramec Power Plant, which is some 10 miles away from the outlying areas of the urbanized portion, and approximately 60,000 tons is released in the Alton - Wood River area. The emissions from these sources affect the air-quality of the City of St. Louis and its immediately surrounding area only at times of specified meteorological conditions and thus cannot be considered

Table 9. EMISSIONS OF SULFUR OXIDES IN
INTERSTATE AIR POLLUTION STUDY AREA, 1963 - 1964

Source category	Emissions, tons/yr	Percent of total
Transportation:	4,400	1.0
Road vehicles	3,600	
Other	800	
Combustion of fuels:	421,000	92.3
Industry	113,000	
Steam-electric utilities	244,000	
Residential	50,000	
Commercial and institutional	14,000	
Refuse disposal	500	0.1
Industrial process emissions	29,600	6.6
Total	455,500	100.0

Table 10. COMBUSTION OF FUELS IN INTERSTATE AIR POLLUTION STUDY AREA, 1963-1964

Fuel	Annual quantity burned	Percent sulfur by weight[a]
Coal (tons/yr)		
Belleville District	5,411,600	3.3
Southern Illinois	1,724,000	1.5
Miscellaneous	250,000	3.0
Residual fuel oil (gal/yr in 1,000's)	106,865	1.6
Distillate fuel oil (gal/yr in 1,000's)	135,233	0.4
Gas (million cubic feet)	131,454	0.0008

[a] As received.

in the same manner as the emissions from the sources located in the area. For the purposes of the following calculations, therefore, only the emissions within the area shown in Figure 2 and tabulated in Table 11 are considered.

Seasonal Distribution of Emissions - Since the emission reduction plan for sulfur dioxide is based on the winter season, only the quantities of pollutants emitted during this time period are considered. The seasonal fluctuation in the emissions from the stationary combustion sources is considerable. The increased space-heating requirements during the winter season increase the use of fuels and hence the emission rates of pollutants. The emission data by political subdivisions for December, January, and February are presented in Table 12. Approximately 36 percent of the industrial emissions of sulfur oxides occur during the winter season, and almost 46 percent of the residential and commercial emissions can be attributed to that period. The data presented in Table 12 were based on the information supplied in the questionnaires for the industrial category and estimated on degree-day data for the domestic and commercial categories.

Geographical Distribution of Emissions - The geographical distribution of pollutant emissions is a determining factor in the resulting ambient concentrations of pollutants. The estimated emissions per grid area presented in Figure 13 indicate that the emissions are highest near the center of the urbanized area. It can also be clearly seen that the emissions arising from a few of the grids are extremely high.

Table 11. EMISSIONS OF SULFUR OXIDES IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA, 1963-1964
(tons/year)

Source category	City of St. Louis	St. Louis County[a]	St. Clair County[a]	Madison County[a]	Entire urbanized area
Transportation	1,800	1,200	600	300	3,900
Combustion of fuels					
Stationary sources	72,260	26,600	51,300	72,300	222,460
Industry	30,500	14,900	23,200	11,000	79,600
Steam-electric utilities	13,760	--	16,000	57,400	87,160
Residential	19,100	9,200	10,800	2,700	41,800
Commercial and institutional	8,900	2,500	1,300	1,200	13,900
Refuse disposal	200	--	100	--	300
Industrial process emissions	--	8,700	14,400	--	23,100
Totals	74,260	36,500	66,400	72,600	249,760

[a] Data are from only the portion of the Study area included within the 394-square-mile central urbanized area of principal interest in the Study.

Table 12. EMISSIONS OF SULFUR OXIDES IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA FOR DECEMBER, JANUARY, AND FEBRUARY
(tons)

Source category	City of St. Louis	St. Louis County[a]	St. Clair County[a]	Madison County[a]	Entire urbanized area
Transportation	400	300	100	100	900
Combustion of fuels					
Stationary sources	26,785	12,380	17,440	22,100	78,705
Industry	10,820	7,000	6,800	4,200	28,820
Steam-electric utilities	3,440	--	5,000	16,100	24,540
Residential	8,450	4,280	4,940	1,240	18,910
Commercial and institutional	4,075	1,100	700	560	6,435
Refuse disposal	60	n[b]	n[b]	n[b]	60
Industrial process emissions	--	2,200	2,800	--	5,000
Totals	27,245	14,880	20,340	22,200	84,665

[a] Data are from only the portion of the Study area included within the central urbanized area of principal interest in the Study.

[b] n = Negligible.

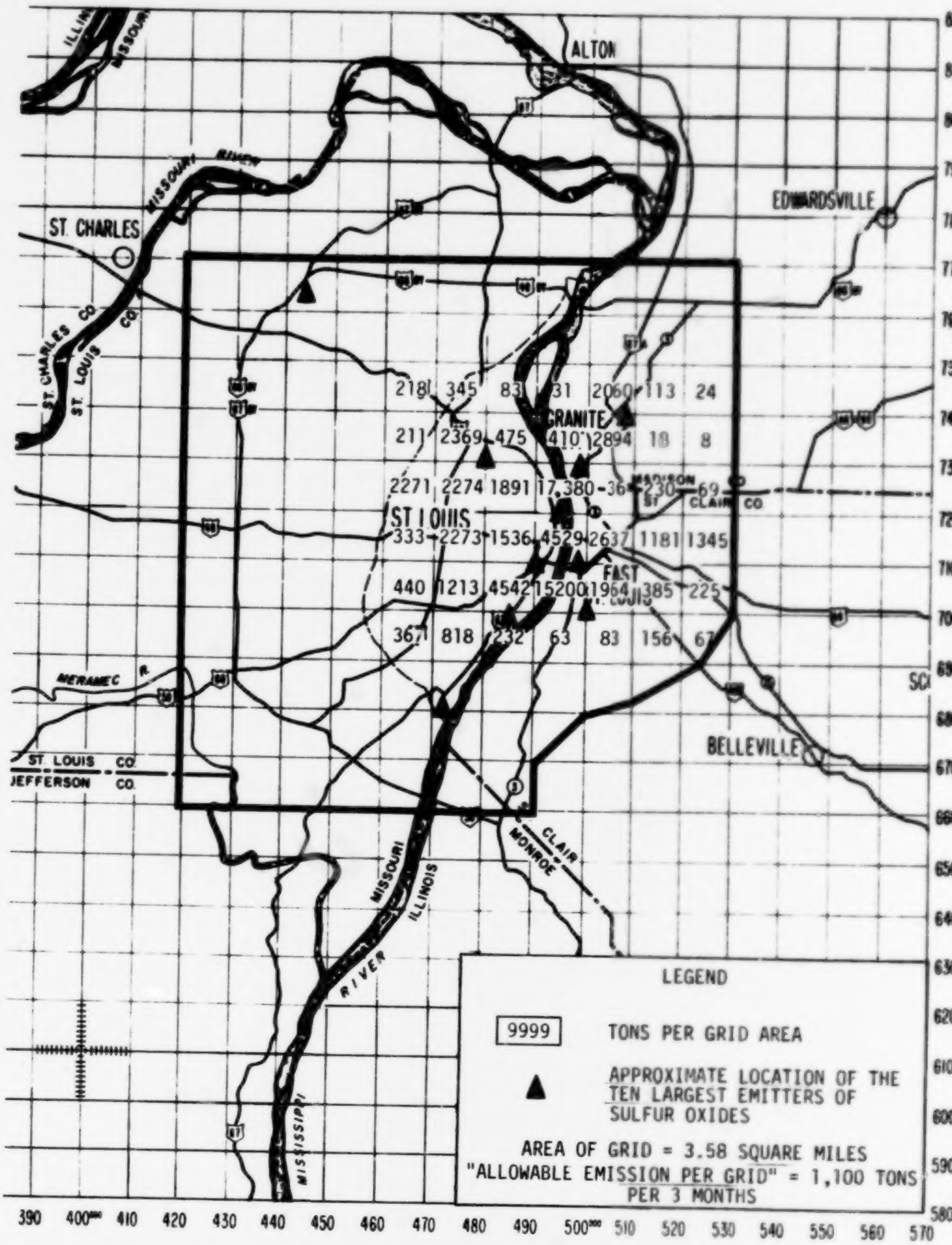

ALTON
EDWARDSVILLE
ST. CHARLES
MISSOURI RIVER
ILLINOIS
MISSOURI
ST. CHARLES CO.
ST. LOUIS CO.
GRANITE
MADISON
ST. CLAIR CO.
ST LOUIS
EAST ST. LOUIS
MERAMEC R.
BELLEVILLE
ST. LOUIS CO.
JEFFERSON CO.
CLAIR
MONROE
MISSOURI
ILLINOIS
RIVER
MISSISSIPPI
218
345
83
31
2060
113
24
211
2369
475
410
2894
18
8
2271
2274
1891
17,380
36
230
69
333
2273
1536
4529
2637
1181
1345
440
1213
4542
15200
1964
385
225
367
818
232
63
83
156
67
LEGEND
9999 TONS PER GRID AREA
▲ APPROXIMATE LOCATION OF THE TEN LARGEST EMITTERS OF SULFUR OXIDES
AREA OF GRID = 3.58 SQUARE MILES
"ALLOWABLE EMISSION PER GRID" = 1,100 TONS PER 3 MONTHS
820
810
800
790
780
770
760
750
740
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580
390
400
410
420
430
440
450
460
470
480
490
500
510
520
530
540
550
560
570

Figure 13. Sulfur oxides emissions per grid area during 3 winter months.

A relatively small number of plants emit large quantities of sulfur oxides. For example, the ten largest emitters of sulfur oxides account for almost 50 percent of the total emissions. The approximate locations of these are also presented in Figure 13. The emission densities by type of land-use and political subdivision are presented in Table 13.

Table 13. DENSITY OF SULFUR OXIDE EMISSION BY TYPE OF LAND USE IN ST. LOUIS - EAST ST. LOUIS CENTRAL URBANIZED AREA - WINTER 1963-1964 (tons/mi^2/3mo)

Land-use category	City of St. Louis	St. Louis County[a]	St. Clair County[a]	Madison County[a]	Entire urbanized area [a]
Residential	390	50	240	70	120
Commercial	1,050	100	190	170	280
Industrial	1,450	1,150	1,400	2,420	1,620
Open space	20	5	5	5	5
All areas	450	70	340	410	210

[a] Data are from only the portion of the Study area included within the central unchanged area of principal interest in the Study.

Relationship of Emission Density and Air Quality

Comparison of Figures 11 and 13, the air quality versus emission density, shows that areas of high emission strengths coincide, for the most part, with those of highest concentrations. Determining a relationship between emission density and the resulting mean ambient air concentrations should, therefore, be possible. One way is to relate the emission density with the mean concentration for considerable areas - areas of at least 20 square miles. For such areas, the net effect of pollutant transfer in or out of the area is minimized and the relative concentrations are primarily dependent upon the emissions originating in the particular area. Another method is to establish a relationship by relating the average concentration for a relatively small area (3 to 4 square miles) with the emission density of that area plus a portion of the emissions of a much larger surrounding area. After an evaluation of both of these methods, the latter was selected for use in developing this air-use plan.

The relationship established between "the effective emission density" and average air quality is presented in Figure 14. This relationship was based on the following simplifying assumptions:

1. With the exception of a few pollutant sources, which will be mentioned later, the average effective stack heights of pollution sources for any grid are relatively uniform throughout the area.

2. The average concentration of sulfur dioxide observed in any one grid is dependent primarily upon the emissions from this and the eight immediately surrounding grids (total area of 32.2 square miles).

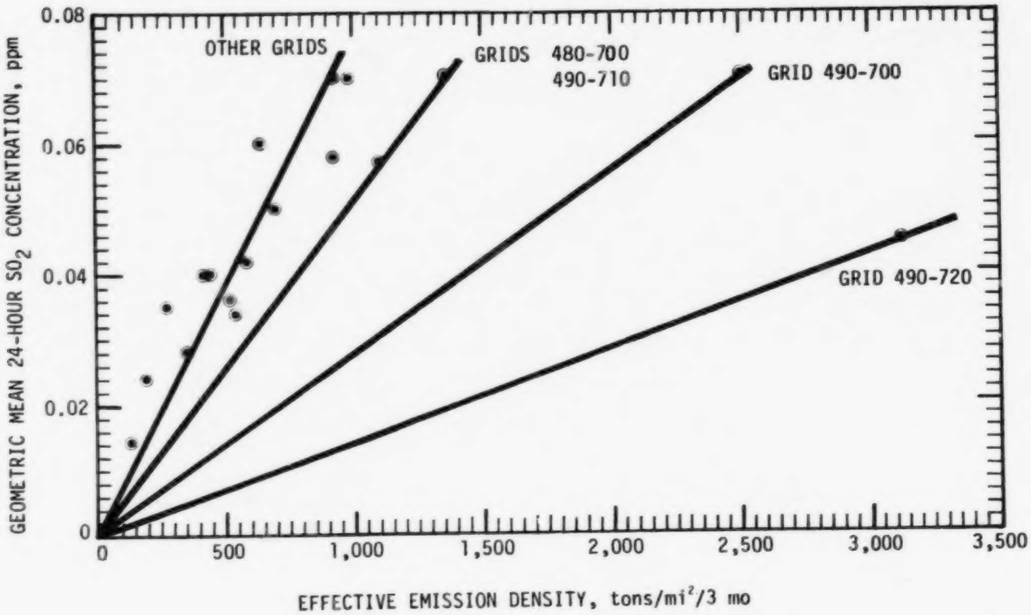


Figure 14. Relationship between sulfur dioxide concentrations and emission density in Dec. 1964 and Jan. and Feb. 1965.

3. The average concentration in any grid is more strongly influenced by the emissions within that particular grid than from the surrounding grids.

4. The emissions in any one grid are uniformly distributed throughout the grid.

5. The hourly and daily distributions of emissions are somewhat similar from grid to grid.

6. The meteorology and topography of the area are relatively uniform.

The mechanics of obtaining this relationship are briefly summarized below.

A 10,000-foot-square grid cell (area = 3.58 square miles), as shown in Figure 2, was selected as the basic unit area. An average 24-hour sulfur dioxide concentration for each of the grids was obtained from the isopleth map shown in Figure 11. An average emission density was calculated for each grid cell. For purposes of relating the average sulfur dioxide concentration with the emission density, an "effective emission density" based on the emissions from that particular grid (central grid) and from the surrounding eight grids was calculated. The assumption made is that the emissions originating more than 3 miles away will not usually have a significant effect on the air-quality of the central grid. Furthermore, since the emissions of the central grid have a more pronounced effect on the concentrations of that grid than from the surrounding eight grids, a weighting factor based on relative distances was included. The "effective emission density" was therefore calculated as follows:

Effective emission density = 0.6 (emission density of central grid) + 0.4 (the average emission density of the eight surrounding grids).

As shown in Figure 14, a good correlation between concentration and "the effective emission density" was found for 12 of the 16 grids considered. As can be seen from the location of the points, the remaining four show a higher emission density for a given average concentration than that obtained by curve 1. All of these four grids contain large emission sources with considerably higher stacks than those in other grids. That the relative stack heights are responsible for this deviation is further supported by the fact that the relative displacement of these four points from the curve for "other grids" is in ascending order of the average stack heights, i.e., the grid containing the Venice Power Plant with an effective stack height of approximately 400 feet being the most displaced point. By reducing the emissions (from the sources with higher stack heights) by a factor of Q/H^2, the relationship between the average concentration and the effective emission density conforms to that shown by the curve for the "other grids."

This relationship is expressed in terms of an average 24-hour concentration of sulfur dioxide and the total emissions during the 3 winter months. This does not seem compatible. It can be used, however, if one considers that the total emissions were distributed in some certain manner during the sampling period and that this distribution of total emissions resulted in the observed concentrations. Since the distribution of emissions with time is not expected to change appreciably, the desired emission density should result in approximately the desired air-quality.

Allowable Emission Density

From Figure 14, it is now possible to obtain an "effective emission density," which corresponds to the desired mean concentration of 0.023 ppm. According to Figure 14, the allowable emission density is approximately 300 tons per square mile for the 3 winter months. Although the 300 tons per square mile is the allowable "effective emission density," as defined previously, it may be used as the actual allowable density for each grid, because each grid in the area has at one time been considered as the "central grid." This value will be used for all grid areas except those containing emission sources of considerably higher stacks than the average of approximately 100 feet or less. For these grids (the displaced points), an allowable emission density may be theoretically obtained by extending a line from the origin through these points and selecting an allowable emission density corresponding to an average sulfur dioxide concentration of 0.023 ppm. Since the line through the points calculated for grids 480-700 and 490-710 are relatively close to the line for other grids, they will be considered in the same manner. The allowable emission densities for the two grids are as follows:

490-720	1,650 tons per square mile
490-700	850 tons per square mile

The qualifying condition for particulates should also apply in this case. This condition states that the allowable emission density of 300 tons total emission per square mile will be emitted during the 3 winter months according to the same hour-to-hour and day-to-day variation as that during the period when the sulfur dioxide concentrations were measured, except in smaller magnitudes. The emission density of 300 tons per square mile represents the limiting density for all areas and land-uses. On the basis of the same arguments as for particulates, different emission densities are assigned to each land-use category. These are given in Table 14.

Table 14. ALLOWABLE SULFUR DIOXIDE EMISSION DENSITIES BY LAND-USE CATEGORY IN ST. LOUIS - EAST ST. LOUIS CENTRAL URBANIZED AREA DURING 3 WINTER MONTHS

Land-use category	Allowable emission density, tons/mi^2/3 mo
Residential	100
Commercial	250
Industrial	550
Open space	235
All areas	300

Emission Reduction Plan

The allowable and existing emissions are summarized in Table 15. Comparison of these two shows that a major reduction in sulfur oxides emissions must be made if the desired ambient air concentrations are to be attained. As in the report section for particulates, the reductions needed for each land-use category are considered individually.

Industrial Land Use - The industrial sources of sulfur oxides emissions include the combustion of coal, oil, and gas; certain processes (sulfuric acid manufacture); and refuse disposal. Since the sulfur oxides emissions from refuse disposal and the combustion of gas are negligible, the allowable industrial emissions given in Table 15 should be allocated among the combustion sources using coal and fuel oil, and the plants emitting sulfur oxides from their processes. The industrial emissions of sulfur oxides for the 3 winter months have been estimated at 58,400 tons. Although the entire industrial area consists of some 36 square miles, most of these industrial emissions originate in two relatively small areas. Approximately 16,000 tons is emitted from one source occupying a small area, and a total of 13,600 tons is released from a group of sources included in an area of less than 4 square miles. The remaining 28,800 tons of sulfur oxides is emitted from sources distributed throughout the Study area.

Table 15. EXISTING, ALLOWABLE, AND PLANNED EMISSIONS OF SULFUR OXIDES IN ST. LOUIS – EAST ST. LOUIS CENTRAL URBANIZED AREA FOR 3 WINTER MONTHS

Subdivision	Land-use category	Land area, mi^2	Sulfur oxide emissions, $tons/mi^2/3$ mo		
			Existing	Allowable	Planned[a]
	Industrial	9.9	14,260	7,695	4,460
City of St. Louis	Residential	21.6	8,450	2,160	2,580[b]
	Commercial	3.9	4,075	975	975[c]
	Open space	25.6	450	6,016	450
	Total	61.0	27,235	16,846	8,465
	Industrial	8.0	9,200	4,400	5,500
St. Louis County[d]	Residential	91.0	4,280	9,100	1,070[b]
	Commercial	11.8	1,100	2,950	1,100[c]
	Open space	107.6	300	25,286	300
	Total	218.4	14,880	41,736	7,970
	Industrial	9.7	14,615	7,135	5,070
St. Clair County[d]	Residential	21.0	4,940	2,100	2,080[b]
	Commercial	3.7	710	925	710[c]
	Open space	26.2	150	6,157	150
	Total	60.6	20,415	16,317	8,010
	Industrial	8.4	20,300	5,610	7,570
Madison County[d]	Residential	19.0	1,245	1,900	450[b]
	Commercial	3.3	565	825	565[c]
	Open space	23.3	100	5,475	100
	Total	54.0	22,210	13,810	8,685
	Industrial	36.0	58,400	24,840	22,600
Central urbanized area	Residential	152.6	18,900	15,260	6,180[b]
	Commercial	22.7	6,450	5,675	3,350[c]
	Open space	182.7	1,000	42,934	1,000
	Total	394.0	84,750	88,709	33,130

[a] Emissions from existing installations after reduction.

[b] Estimated 1975 emissions based on complete elimination of open burning and natural decline in use of coal as heating fuel.

[c] Arbitrary estimate.

[d] Data are from only the portion of the Study area included within the central urbanized area of principal interest in the Study.

For purposes of calculating emission limitations, the two grid cells of high emissions are considered individually and separately from the rest of the area. Both cells were assumed to be entirely industrial for the following reasons. The emission rates of sulfur oxides from these areas are extremely large, the elevations at which emissions are discharged are much higher than the average, and land-use data for small areas were not available. The estimated average stack heights are rough approximations, and only their order of magnitude is of significance. The "planned emissions" refer to the emissions resulting from the control of combustion sources according to the allowable emission rate given in terms of pounds of sulfur oxides per million Btu heat input, and for industrial process sources according to the proposed emission limitations. The allowable emissions were calculated on the following emission densities; 1,650 tons per square mile for grid 490-720, 850 tons per square mile for grid 490-700, and 550 tons per square mile for the other industrial areas considered collectively. As shown in Table 16, the planned emissions for the industrial areas considered collectively are less than the allowable. This difference is the amount allowable for future increase in emissions.

As noted previously, the planned emissions from sulfuric acid manufacturing processes were calculated on the basis of 30 pounds of sulfur oxides per ton of acid produced. This corresponds to a conversion efficiency from sulfur dioxide to sulfur trioxide of approximately 97.5 percent, which is attainable with the processes in use. The existing emission rates of sulfur oxides were calculated on the basis of 45 pounds per ton of acid produced.

The planned emissions from the combustion of coal and fuel oil were determined from the existing quantities of fuels burned. Allowable emission rates selected were 2.3 pounds of sulfur oxides per million Btu heat input for the industrial areas considered collectively and approximately 1.4 pounds and 0.7 pound respectively, for the individually considered grids. The emission rate corresponding to 2.3 pounds per million Btu heat input is equivalent to burning coal containing 1.4 percent sulfur and fuel oil containing 2.0 percent sulfur. In the absence of sulfur dioxide removal systems, these are the recommended limitations on the types of fuels to be allowed in the area. The 1.4 percent sulfur content for coal was calculated on an as-received basis using the average heating value of 11,300 Btu per pound. Assuming that the average moisture content of coal is approximately 10 percent by weight, the allowable sulfur content in coal if analyzed on a dry basis would be approximately 1.6 percent.

The above limitations refer only to the sources included in the general category and not to the major sources in the two previously mentioned grids. For the major sources located in these two areas, specific calculations relating to emission limitations are needed. Factors such as stack heights, diffusion characteristics, expected life of sources, and costs should be considered in these calculations. Calculations for one area have been made and used in program development activities.

Table 16. EXISTING AND ALLOWABLE EMISSIONS OF SULFUR OXIDES FROM INDUSTRIAL AREAS IN ST. LOUIS - EAST ST. LOUIS CENTRAL UBRANIZED AREA

Location	Land area, mi^2	Sources of emissions	Estimated average stack height, ft	Sulfur oxides emissions, tons/3 mo			Allowable emission rate, lb SO_2 per 10^6 Btu
				Existing	Allowable	Planned	
Grid 490-700	3.6	Coal	150	13,330		1,920	0.68
		Fuel oil		50			
		Processes		1,620		1,080	
		Total		14,970	3,060	3,000	
Grid 490-720	3.6	Coal	225	17,000		5,940	1.36
		Fuel oil		8		0	
		Processes		0		0	
		Total		17,008	5,940	5,940	
Other grids (cumulative)	28.8	Coal	100 or less	19,960		11,410	2.0
		Fuel oil		3,040			
		Processes		3,380		2,250	
		Total		27,325	15,840	13,660	
Total	36.0	All sources		58,400	24,840	22,600	

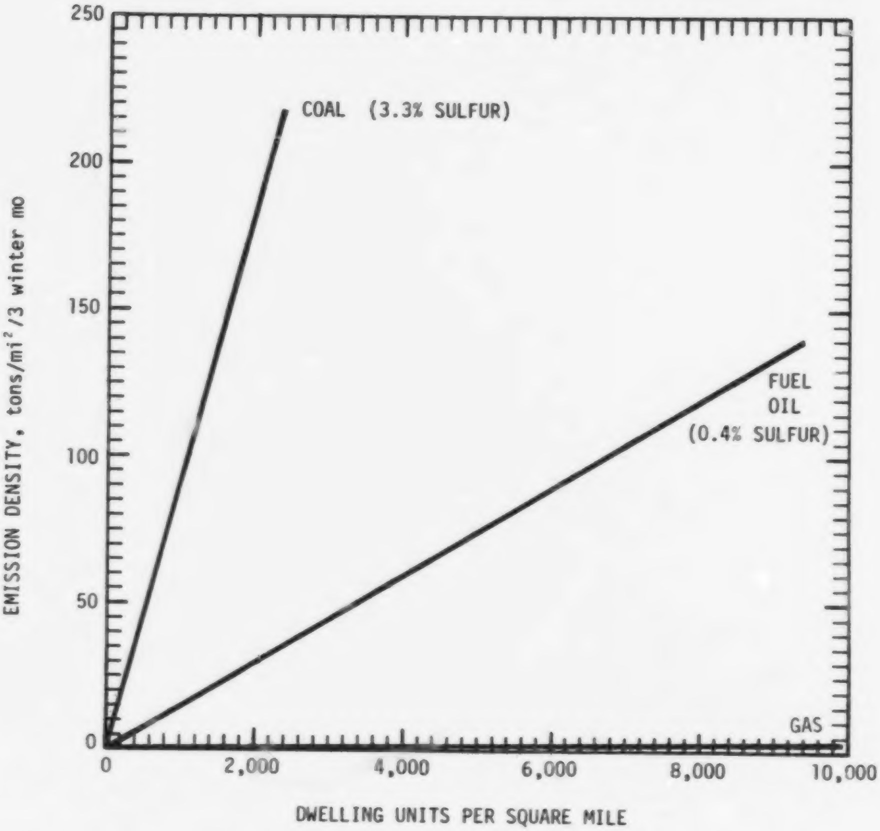


Figure 15. Sulfur oxide emissions from burning of coal, fuel oil, and gas in residential heating units.

Residential Land Use - An allowable emission density of 100 tons per square mile for the 3 winter months has been previously selected. As shown in Figure 15, this would correspond to the emissions expected from 1-square-mile areas occupied by 500 dwelling units using coal, 6,700 using 0.4 percent sulfur distillate fuel oil, or an unlimited number using gas. According to the existing population densities, only the most populated areas would exceed the density requirements if all dwelling units used oil.

The existing emission densities for residential areas range from an average of 50 tons per square mile in St. Louis County to an average of 390 tons per square mile in St. Louis City. The residential emissions are highest in areas where coal is used. If this decline in the use of coal continues, the expected emissions from residential sources in 1975 would be as shown in Table 15. A comparable reduction in emissions can be achieved sooner if the sulfur content of the fuels is lowered to the limits specified for industrial installations. A sizeable reduction in residential emissions is expected to have a more pronounced effect on the reduction of the ambient air concentrations of sulfur dioxide than comparable reductions in other source categories. This is primarily due to the proximity of the source to the receptor, the wide geographical distribution of sources, and the generally low elevations of emission discharge points. Because of the significant influence of residential emissions on sulfur dioxide ambient air concentrations, especially in areas where people live, fuel limitations proposed for industrial sources are recommended for the fuels burned in households. This change would improve air-quality sooner than could be expected from the natural decline in the use of coal.

Commercial Land Use - An allowable emission density of 250 tons per square mile was selected for the commercial land-use areas. Presently, an estimated 6,150 tons of sulfur oxides is released from the commercial areas, and on this basis an average reduction of slightly less than 20 percent is needed. An average reduction basis, however, is misleading because most of these emissions come from areas in the City of St. Louis, where an average reduction of 76 percent is needed.

Because very little information on the sizes of combustion equipment in the commercial sources is available, estimating the control measures needed to reduce the emissions is difficult. It is suggested that the limitations prescribed for industrial and residential sources be extended to include the commercial establishments so that the needed reductions can be achieved.

Open Space - An allowable emission density of 235 tons per square mile has been proposed for unused land and road space collectively. The existing emissions from this land-use category include only the pollution arising from transportation sources, which do not emit much sulfur dioxide.

As pointed out earlier, a rather high allowable emission density was assigned to this land-use category to provide a safety factor for future expansion. An allowable emission density of approximately 300 tons per square mile has been provided in the event that half of the open space is eventually developed.

Summary - Presently an estimated 84,750 tons of sulfur oxides is emitted to the air during the 3 winter months. According to the emission reduction plan, these emissions will be reduced to approximately 33,130 tons for an overall reduction of approximately 61 percent. The plan calls for reductions in all of the major source categories and in all of the land-uses. The added dilution provided emissions from high elevated sources was considered by allowing such sources to emit considerably larger quantities.

If the industrial sources were controlled according to the emission limitations specified, a reduction to 48,950 tons of sulfur oxide emissions during the winter season would result. This reflects only the decrease in existing emissions without adding emissions for new sources in the area. Of this reduction, the major decrease in emissions would need to take place in the stationary combustion sources using coal. Although a quantitative estimate of the impact of the emission reduction plan upon emissions from commercial areas cannot be made, the measures prescribed would presumably be sufficient to reduce the emissions within the allowable limits. In the residential category the emission reduction resulting from both the decline in the use of coal and the burning of coal of lower sulfur content is expected to reduce the emissions by approximately 12,720 tons during the winter season. As shown in Table 15, the proposed controls are expected to result within the allowable emission limits.

Another method that has been used elsewhere for determining the reductions in emissions needed to attain the desired air-quality is predicated on the assumption that the emissions should be reduced by the percentage that the air-quality goal is exceeded by present concentrations in the worst area. Using this method of calculating the percent reduction needed in sulfur oxides emissions results in an overall emission reduction of 76 percent. As would be expected, this is somewhat higher than the 61 percent obtained through the methodology used here.

Recommendations For Control Regulations - In the preceeding subsections reductions in sulfur oxides emissions are determined to meet the allowable emission densities in each of the four major land-use categories and each political subdivision. The ways in which these reductions should or can be achieved depend primarily on the available technology and are dictated, at least in part, by various socioeconomic factors. Wherever possible, however, these have been considered in the drafting of the recommendations relating to the control of sulfur oxides emissions.

In the interests of attaining the air-quality goals for sulfur dioxide as soon as possible, the following recommendations concerning the use of sulfur-bearing fuels and regulation of emissions of sulfur oxides are made. Since, however, the established fuel-use patterns cannot be changed immediately, the achievement of the desired emission levels is expected to occur through a series of steps that may require 5 to 10 years for full implementation.

Washing of Coal - An indirect means of reducing the sulfur oxides in stack exit gases is to reduce the sulfur content of the fuels burned. A certain portion of the sulfur present in coals may be removed by washing the coal. The City of St. Louis presently requires washing of all coal of 2 percent sulfur or more or 12 percent ash or more. The effectiveness of removing sulfur by washing depends on the quantity of pyritic sulfur in the coal and on the washing techniques used. The coals used in the St. Louis area for the most part contain 2 percent or more of organic sulfur, which cannot be removed by any washing techniques. Although washing the coal will not reduce the sulfur dioxide emissions from the organic portion of the sulfur in coal, it will reduce the emissions from pyritic sulfur and should therefore be continued.

Emissions of Sulfur Oxides from Industrial Processes - Wherever improved efficiency of existing plant operations will reduce sulfur oxides emissions, such improvement should be made, especially if the emissions add appreciably to the existing ambient air concentrations where people live.

Emissions of Sulfur Oxides from Fuel-Burning Installations of Rated Plant Capacities of Less Than 2,000 Million Btu Per Hour - As noted previously, achieving the allowable emission rate of 2.3 pounds of sulfur oxides per million Btu heat input places a limitation on the sulfur content of the fuels used. For coal, this has been calculated as 1.4 percent (as-received basis) and for fuel oil as 1.6 percent. As a first step in sulfur oxides reduction, these fuel limitations are proposed only for the heating season.

The schedule for implementing the sulfur oxides allowable emission rates depends upon the time necessary to develop the capabilities to supply the required quantity of 1.4 percent sulfur coal, which may require opening new mines. In a provision for a suggested-ordinance the burning of low-sulfur coal is urged within 2 years after the enactment of the ordinance. If a gradual transition to the use of low-sulfur coal is advantageous, the complete transition could be effected over a 3-year period. In this event, the burning of low-sulfur coal should be started initially during the months of December and January when the sulfur dioxide levels are the highest and then subsequently extended to include the other 4 space-heating months.

An estimated 1,400,000 tons of low-sulfur coal per year is needed. This is the quantity of high-sulfur coal presently burned in the urbanized area (Figure 2) during the 6-month heating season by the industries, households, and commercial establishments. This amount is only 20 percent of the annual consumption of coal in the Study area.

According to the U.S. Bureau of Mines [1] and the Illinois State Geological Survey, [2] coals of low enough sulfur content required to meet the sulfur content requirements could probably be supplied from the Illinois coal fields. On the basis of average costs supplied by the U. S. Bureau of Mines, an increase of 25 percent in the cost for coal with a sulfur content of less than 1.5 percent can be expected. Since an estimated 1,400,000 tons of low-sulfur coal is needed annually, the total cost to the community is estimated at $1.9 million per year. If sulfur content is limited to 2 percent and the availability of coal increases, the additional cost would be an estimated $1.3 million per year. Whereas the use of coals containing 1.5 percent sulfur is expected to result in reaching the 0.1 ppm air-quality goal, the use of coal containing 2 percent sulfur is projected to result in a 99 percentile concentration of 0.12 ppm over a considerable part of the central urbanized area. This concentration is above the air-quality goals; therefore, in making a decision on fuel requirements, the effect on air-quality should be considered as should the possibility of reaching the goals in more than one step. The above calculations relating to air-quality levels were made on the assumption that the emissions from steam-electric power plants are controlled to the required limits. If low-sulfur coal is not available in Illinois, and must be obtained elsewhere, additional shipping costs would increase the cost of coal. Whether this coal is to be supplied from the Illinois coal fields or elsewhere is primarily a question of availability and economics, which can best be resolved through channels other than those available to the Interstate Air Pollution Study Project Executive Committee.

Although this suggested regulation requires only a partial change to lower sulfur coals, the needed alterations can, however, have long-range implications requiring concentrated and combined efforts to reach the most feasible way to supply the needed quantities of low-sulfur coals. To assure that the air-quality goals for sulfur dioxide are reached as soon as possible, an annual reevaluation of the factors involved by means of hearings is recommended. Such hearings would initially serve to inform the public of the progress made in developing the resources of low-sulfur coals and to evaluate the effectiveness of the reductions in emissions achieved through the use of the various control measures.

Emissions of Sulfur Oxides from Fuel-Burning Installations of Rated Plant Capacities of 2,000 Million Btu Per Hour or More - More than half of the sulfur oxides, 235,000 tons per year, and 22,400 tons per year of particulates originate from steam-electric utility plants. Atmospheric diffusion of these pollutants is influenced considerably by high stacks as well as topography and probably heat-island effects. The numerous alternatives for handling these emissions involve factors beyond the authority and technical scope of the Project Executive Committee. This report, therefore, in an ordinance provision, suggests inclusion of a time deadline for limiting emissions from steam-electric utilities. To assure action, the formation of an officially constituted committee to prepare an emission reduction plan for this type of air pollutant source is recommended. The plan should consider at least particulates, sulfur oxides, and nitrogen oxides. It should consider any steam-electric utility plant that may contribute pollutants to the Study area. The committee would be composed of individuals representing the following: steam-electric utilities, universities, industrial science, weather bureau, and the public, with an elected public official as a member ex-officio. The group would select its own chairman, obtain reports and consultant help as needed, and present within a 2-year period after appointment, a plan indicating alternatives, costs, and time schedules to reach air-quality goals.

AIR-USE PLAN - HYDROCARBONS

Hydrocarbons are discharged to the air from a variety of sources, but the most important sources are gasoline-powered vehicles and burning of refuse material. In 1963, an estimated 373,900 tons of total hydrocarbons was discharged to the air of the St. Louis Metropolitan Area. Of this total, 63 percent was attributed to the automobile and 22 percent to the burning of refuse material. Evaporation of solvents contributes 10 percent, industrial process losses, 3 percent and the combustion of fuels, 1.7 percent.

The reactive type of hydrocarbon, is one of the precursors of oxidants and consequently photochemical smog. This property of hydrocarbons is of primary concern and requires that means for reducing hydrocarbon emissions be developed and implemented. The automobile and refuse disposal are closely linked to the needs of inhabitants and are therefore expected to increase as population growth continues. Vehicle gasoline consumption in the Study area is expected to double by 1980. Refuse material generated is expected to increase at a rate comparable to the population increase, with an expected increase of almost 40 percent by 1980. Increases in the emissions from the other source categories will undoubtedly follow the population increase.

Air-Quality Goals

Air-quality goals, as such, are not prescribed for hydrocarbons. As noted previously, it is primarily total oxidant in the atmosphere that causes harmful effects and is of primary concern. The air-quality goal for total oxidant of 0.15 ppm (potassium iodide colorimetric method of measurement) has been suggested as the maximum permissible 1-hour average concentration. The effects of oxidant levels above 0.15 ppm on visibility, eye irritation, and vegetation damage are discussed in detail in Volume VI of this report.

Existing Concentrations

Total oxidant in the air was measured at nine Study sites from May through October 1964. The method of measurement was the phenolphthalein method, which gives results approximately twice as high as those with the potassium iodide colorimetric method. In addition, since March 1964 total oxidant has been monitored continuously at the Continuous Air Monitoring Program (CAMP) station. Data obtained at the nine sites indicated that the smog odor level of 0.15 ppm was exceeded 4 percent of the time, and the eye irritation level of 0.25 ppm was exceeded 1 percent of the time. The highest concentration observed during this sampling period was 0.30 ppm at site 449-719, about 2 miles west of the city limits of St. Louis. The maximum monthly average during this sampling period was 0.06 ppm in July 1964.

At the CAMP station, the monthly mean concentrations varied from 0.013 ppm in December 1964 to 0.04 ppm in May 1964. A maximum 24-hour average concentration of 0.07 ppm was measured several times in April, June, and July. The maximum 1-hour concentration observed was 0.26 ppm in July.

Comparison of the observed concentrations of total oxidant in the air with the air-quality goal of 0.15 ppm as the maximum permissible 1-hour concentration shows that the air-quality goal is exceeded 4 percent of the time during the summer months. Similarly, the maximum 1-hour average concentration for each month, except May 1965, was higher than 0.15 ppm. Using the nine-station network measurements as representative of the existing oxidant levels, a reduction in oxidant levels by approximately a factor of 2 may be needed to reach the air-quality goal.

Existing and Projected Emissions

Emissions of Hydrocarbons From Transportation Sources - In 1963, an estimated 236,000 tons of total hydrocarbons was released by all transportation sources in the area. The hydrocarbon emissions from gasoline-powered vehicles in 1963 were estimated at 239,800 tons. The importance of aircraft, vessels, and diesel-powered vehicles as a source of hydrocarbons is relatively minor (2 percent) and for the purposes of this discussion will be assumed to be insignificant.

Gasoline Consumption - Existing and Projected - In 1963, approximately 759 million gallons of gasoline was burned in the Study area. Gasoline consumption in the Study Area is expected to increase to 1.4 billion gallons per year by 1980. In accordance with the national trend, the 1980 figure will be doubled again by 2000. The rate of increase in gasoline consumption far outweighs the growth in population, which has been projected as approximately 43 percent between 1960 and 1980. The ever-increasing number of vehicles per family and the increasing distances of travel in urban areas are expected to produce the anticipated increase in gasoline consumption. Projections of gasoline consumption for the Study area are shown in Figure 16. A considerable reduction in the projected consumption rate would undoubtedly result if an extensive mass transit system is implemented or a radical change in the mode of travel comes into effect.

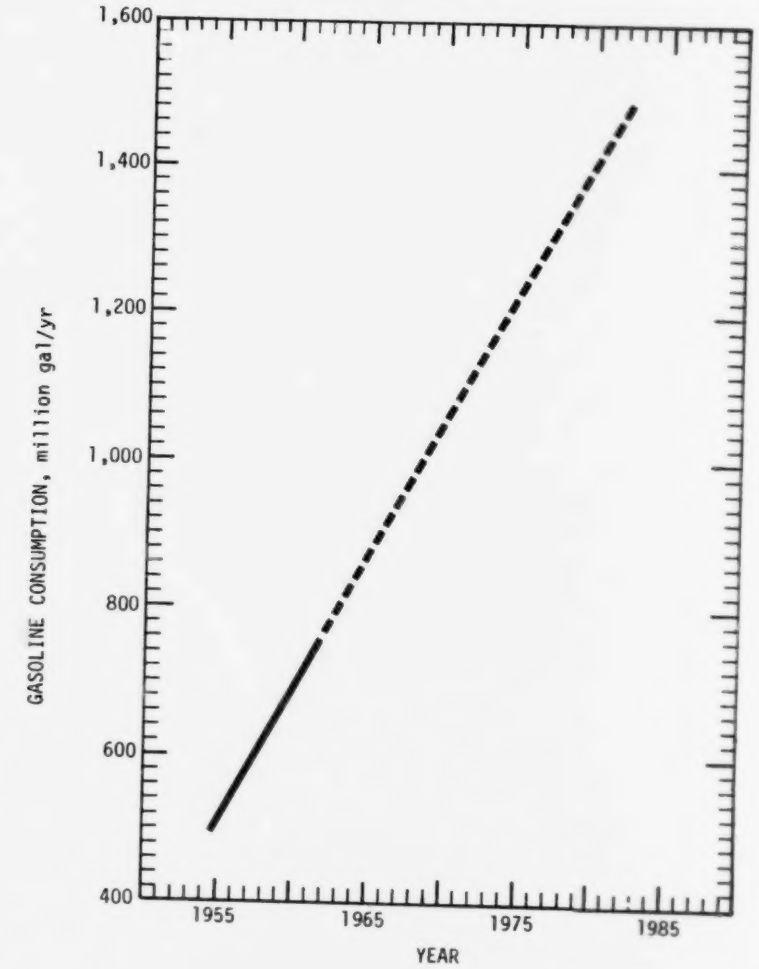


Figure 16. Projected gasoline consumption in Interstate Study Area.

Emissions of Hydrocarbons - The emissions of total hydrocarbons, if uncontrolled, would increase proportionately with gasoline consumption and would reach an annual emission of 472,000 tons in 1980. This is an increase of 100 percent over the estimated 1963 emissions. The impact this increase on deterioration of the air-quality in the central part of the urbanized area will be even more significant since most of the emissions from motor vehicles occur in this limited area.

The effect that the various reduction devices, presently proposed for installation on new vehicles, would have on the emissions of total hydrocarbons in the Study

GPO 805-084-3

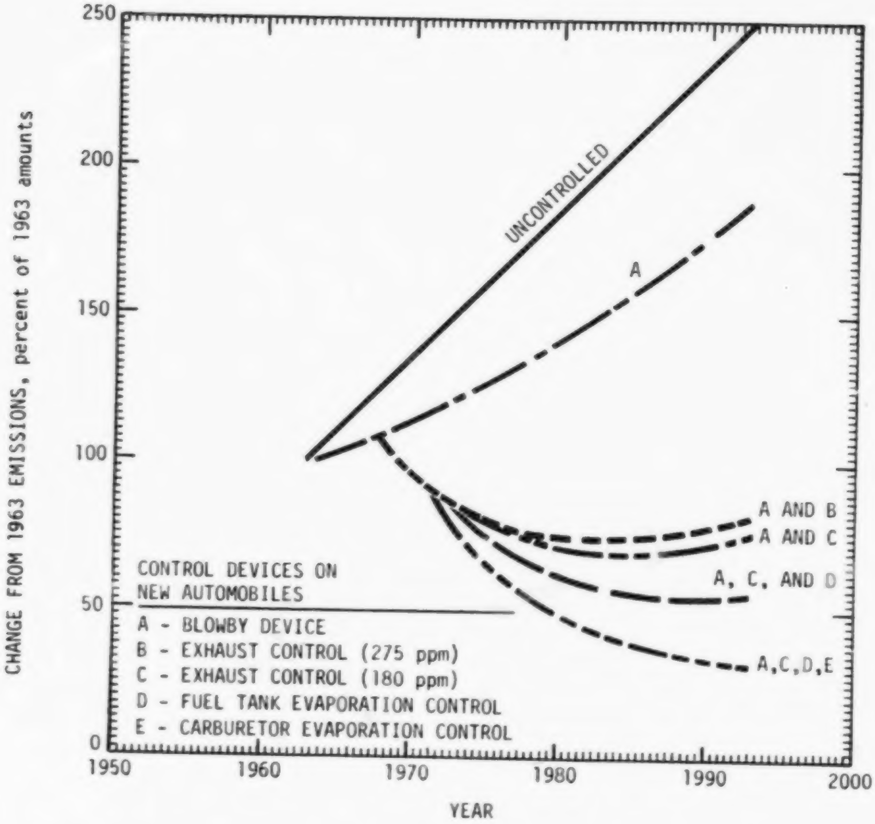


Figure 17. Projected hydrocarbon emissions from gasoline-powered motor vehicles - without control and with various combinations of control.

area are shown in Figure 17, 18, and 19 and are discussed below. Included are all reduction measures and devices ranging from those in use at the present to those expected to be developed in the years to come. For the latter it has been necessary to estimate the reduction efficiencies expected to result from the various control devices.

The existing and anticipated control devices, their efficiencies in removing total hydrocarbons, and the year they are expected to be in use are summarized in Table 17. The emission rates presented in Table 17 represent the emissions under average urban driving conditions.

As shown in Table 17, five individual control measures have been assumed, with the year of implementation ranging from 1963 to 1971. Starting with the 1963 models, all gasoline-powered vehicles are equipped with a crankcase blowby control device. This device reduces crankcase emissions 85 percent by venting the piston blowby gases from the crankcase back into the intake manifold of the combustion chambers. The blowby device costs $5.00 to $10.00 factory installed and

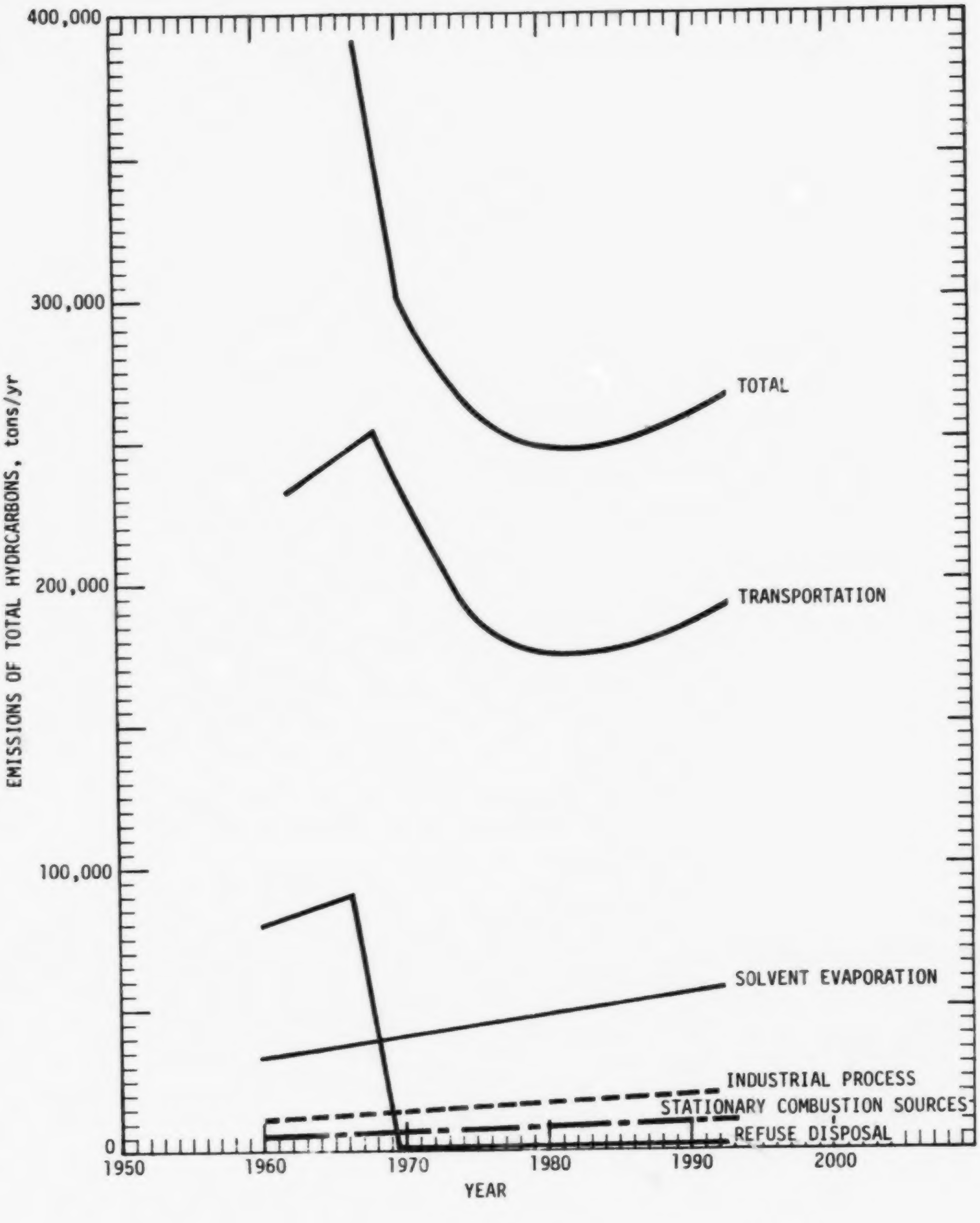


Figure 18. Projected total hydrocarbon emissions - plan I.

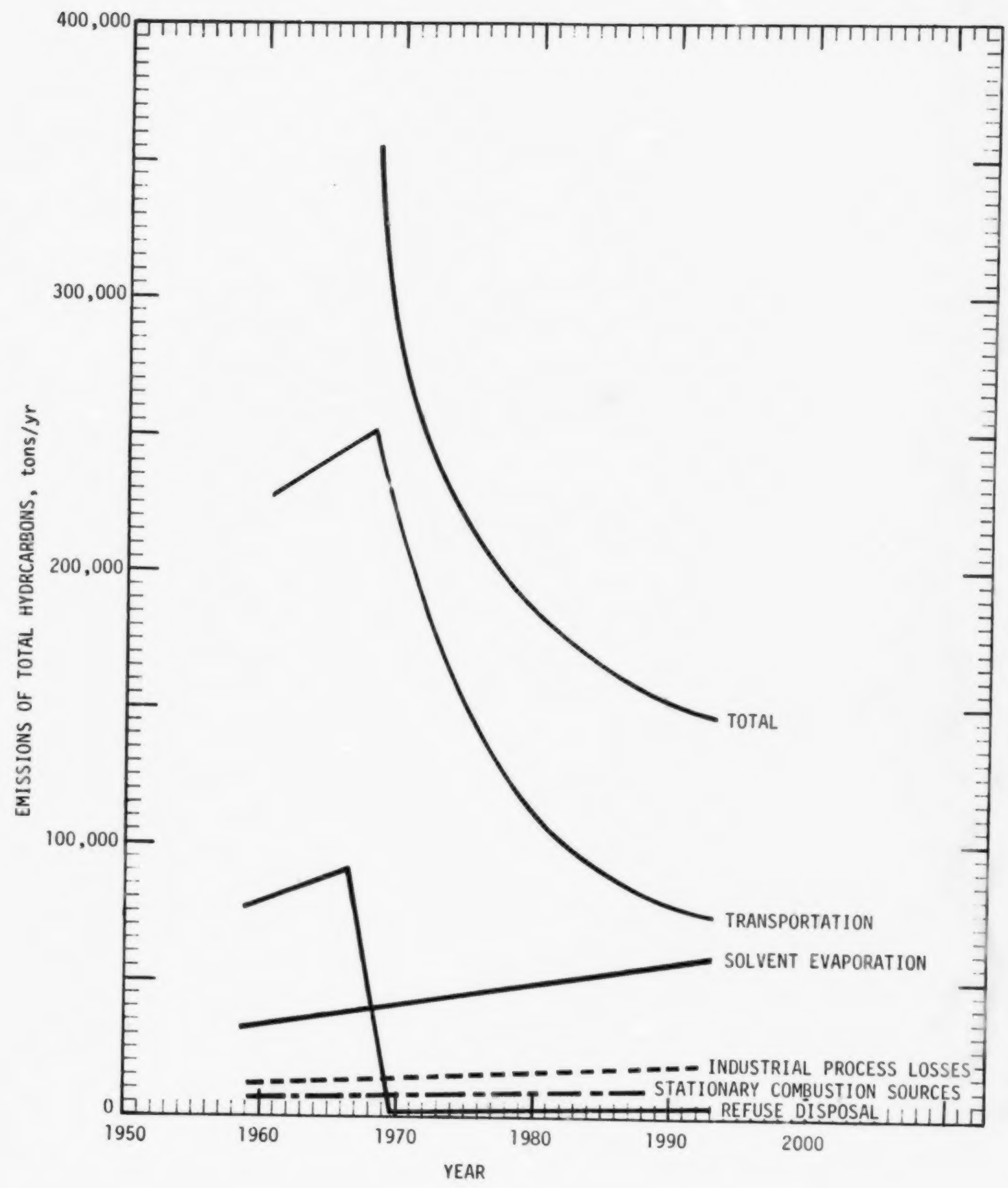


Figure 19. Projected total hydrocarbon emissions - plan II.

Table 17. EMISSION RATE OF HYDROCARBONS
(lb/automobile/day)

Source of emission	Year			
	1962[a]	1963[b]	1968[c]	1971[d,e]
Exhaust	0.363	0.363	0.073	0.048
Crankcase	0.216	0.032	0	0
Evaporation				
Fuel tank	0.068	0.068	0.068	0.014
Carburetor	0.091	0.091	0.091	0.018
Total	0.738	0.554	0.232	0.080
% of 1962	100.0	75.1	31.4	10.8

[a] Values for 1962 are based on experimental data measured at 25 mph for a typical cycle, taken from: Rose, A. Summary Report of Vehicular Emissions and Their Control. Presented at ASME Meeting, Chicago, Ill.

[b] In 1963, blowby devices installed on all new cars, assumed to be 85% effective.

[c] A control device limiting exhaust emissions to 275 ppm to be installed on all 1968 cars. Starting with 1968 models, the blowby device assumed 100 percent effective.

[d] A control device limiting exhaust emissions to 180 ppm installed on all 1971 models.

[e] Reduce fuel tank and carburetor emissions by 80% on 1971 model cars.

$12 to $25 when added to a used vehicle. The overall reduction of hydrocarbon emissions from a motor vehicle equipped with this device is approximately 25 percent.

The passage of Federal Law S-306 in 1965 authorized the Secretary of Health, Education, and Welfare to set limitations on air pollutant emissions from motor vehicles. The specified regulations require the complete elimination of crankcase emissions and limit the hydrocarbon emissions in the exhaust to 275 ppm (measured as hexane). These limitations will go in effect starting with the 1968 models.

The uncontrolled concentration of hydrocarbons in the exhaust gases are of the order of 1,365 ppm under the average urban driving conditions. There are several means available to achieve the desired emission rate. The control costs vary accordingly, but an average cost of approximately $50 per unit is probably a reasonable estimate. The overall reduction in emissions from motor vehicles equipped with exhaust as well as 100 percent effective blowby control devices is expected to be approximately 69 percent.

Assuming that a requirement for additional reduction in hydrocarbon emissions in the exhaust gases to 180 ppm, as required in the State of California, is adopted nationwide and implemented starting with the 1971 models, a reduction of 72 percent of the uncontrolled hydrocarbon emissions would result.

Further reductions in hydrocarbon emissions from the evaporation from the fuel tank and carburetor have been assumed to be implemented starting with the 1971 models. This reduction is assumed to result from controlling the evaporation losses from the fuel tank and carburetor by approximately 80 percent. The assumed effectiveness of these reductions was based on work and requirements of the State of California. The implementation of these control measures would result in an overall reduction of emissions per equipped vehicle of approximately 89 percent.

The percent reductions achievable by the various control measures and the data given in Table 17 refer to the emission rates of hydrocarbons from vehicles equipped with these control devices. These data coupled with projected gasoline consumption (Figure 16) and information on retirement schedule of automobiles,[3] were used to project the emissions of hydrocarbons in the St. Louis Metropolitan Area. These projections were based on two additional assumptions, (1) only new cars are equipped with the control devices and (2) the efficiency of control devices remains unchanged through the life of the vehicle. It is expected, however, that routine inspections will be needed to maintain the efficiencies of these devices within the specified limits.

Figure 17 shows the percent reduction achievable by the various control means. The emissions are expressed as percent of the 1963 hydrocarbon emissions. The curves reflecting the effect of the various control means are, as plotted in Figure 17, based on the assumption that all the intermediate measures have been implemented at the time specified in Table 17. It is evident that controls other than the blowby device are needed to reduce the hydrocarbon emissions below the 1963 emissions.

The reduction in emissions achieved by the use of the blowby device (in use since 1963) and the exhaust control to 275 ppm (starting with 1968) can be considered as relatively accurate estimates. The other reductions are only in the speculative stage and should be interpreted as rough approximations.

Emissions of Hydrocarbons From Refuse Disposal - An estimated 1,328,600 tons of combustible refuse material was generated in the Study area during 1963. A breakdown by the modes of disposal used and the quantities of hydrocarbons released are presented in Table 18. In 1963, approximately 45 percent of the combustible refuse generated was burned at dumps and on-site. These modes of disposal accounted for 84,300 tons of hydrocarbons, or 99.5 percent of the total, released by refuse disposal.

Generation and disposal of combustible refuse - Assuming that the present average of 3.4 pounds of combustible refuse material per capita per day remains unchanged, the quantity of refuse material generated in 1980 would be approximately 1,835,000 tons. At present only about 20 percent of the combustible refuse is being

Table 18. EMISSIONS OF HYDROCARBONS FROM REFUSE DISPOSAL IN 1963 - INTERSTATE AIR POLLUTION STUDY AREA

Mode of disposal	Refuse, tons/yr	Total hydrocarbons released, tons/yr
Incineration		
Municipal	223,000	33
On-site	62,600	363
Landfill	441,000	--
Open burning		
Dumps	284,000	44,500
On-site	318,000	39,800
Total	1,328,600	84,696

incinerated within municipal or on-site units. Open burning for disposal of wastes will undoubtedly decrease because the recommended reduction plan for particulates calls for (1) elimination of open burning and (2) multiple-chamber design for all incinerators. These recommendations, when acted on, will result in a considerable reduction in the emissions of hydrocarbons.

Emissions of hydrocarbons - On the basis of the above and the presently available emission factors, the emissions of hydrocarbons for future years were calculated. The following assumptions were made for these calculations: (1) 441,000 tons per year of refuse is and will continue to be disposed of by sanitary landfill, (2) all existing incinerators will be converted to multiple-chamber types, (3) the quantity of refuse presently disposed of by open burning will be incinerated, and (4) the additional quantity of refuse generated because of population growth will be incinerated. January 1, 1969, has been assumed as the completion date for actions required by these four items.

Emission factors indicate that during the incineration of a ton of refuse, a municipal incinerator releases 0.3 pound of hydrocarbon and an industrial or commercial multiple-chamber incinerator releases 0.25 pound of hydrocarbon. Since these emission factors are relatively close, an average of 0.30 pound of hydrocarbons has been assumed for both types of incinerators.

The estimated hydrocarbon emissions for 1963 and the projected emissions for future years are shown in Table 19. The elimination of all open burning and the conversion to multiple-chamber types is expected to reduce the hydrocarbon emissions by approximately 99.8 percent. The validity of the emission factor of 280 pounds per ton for open burning used in this calculation is open to some question. Regardless of future findings, the expected reduction will be large and, therefore, will reduce the hydrocarbon emissions from this source category to a relatively insignificant amount.

Table 19. PROJECTIONS OF HYDROCARBON EMISSIONS FROM REFUSE DISPOSAL IN INTERSTATE AIR POLLUTION STUDY AREA
(tons/yr)

Mode of disposal	Year		
	1963	1969	1980
Municipal incineration	33	159	219
On-site incineration	363		
Landfill	--	--	--
Open burning	84,696	--	--
Total	85,092	159	219
% of 1963 total		0.2	0.3

Emissions of Hydrocarbons From Other Sources - "Air Pollution Emission Inventory," Volume II of this report, lists other sources of hydrocarbons as solvent evaporation (including gasoline from stationary sources), industrial process losses, and fuel combustion. Collectively, these source categories contribute slightly more than 14 percent of the area total, or an estimated 53,900 tons of hydrocarbons annually. They include approximately 24,000 tons from the solvents used in industries and dry cleaning plus other non-industrial uses. An additional 12,000 tons per year is added from the evaporation of gasoline from storage tanks and the filling of automobile fuel tanks. Industrial processes annually emit an estimated 11,700 tons, which is probably low, since information relating to some industries was not available. The combustion of fuels (primarily coal) contributes another 6,200 tons annually.

For the purposes of predicting future emissions of hydrocarbons, the emissions from sources considered in this subsection were increased for future years proportionately to the expected increase in population. They appear in Table 20.

Emission Reduction Plan

The mathematical relationship between hydrocarbons and oxidant concentrations could not be found. (See Volume III of this report.) For this reason, it is not possible to predict reductions in oxidant levels based on hydrocarbon reductions. It is known, however, that oxidant levels should be reduced to meet the goal and that hydrocarbon reduction is one way to do it.

Two separate projections of hydrocarbon emissions are presented in Figures 18 and 19. The Plan I projections shown in Figure 18 considered only the reductions in motor vehicle hydrocarbon emissions that are in effect now or are pro-

Table 20. EXISTING AND PROJECTED EMISSIONS OF HYDROCARBONS FROM OTHER SOURCES[a] IN INTERSTATE AIR POLLUTION STUDY AREA
(tons/yr)

Source category	Year		
	1963	1970	1980
Solvent evaporation	36,000	41,000	49,800
Industrial processes	11,700	14,500	16,000
Stationary combustion sources	6,200	7,500	9,000
Total	53,900	63,000	74,800

[a] Projections were made on the basis of controls presently in use.

vided by existing regulations (curve labeled "A and B" on Figure 17) and do not include the expected decreases that are still in the speculative stage. The Plan II projections shown in Figure 19 were made on the basis that all of the controls stated would, in fact, be implemented (curve labeled "A, C, D, and E" on Figure 17).

Figure 18 shows that a considerable reduction in hydrocarbon emission may be attained in the next few years as a result of the recommended changes in refuse disposal practices and to a lesser extent the increasing number of automobiles equipped with the blowby control devices. The reduction in emissions after 1969 would occur as a result of controls on motor vehicle exhaust emissions.

The reductions shown in Figure 19 are more spectacular than those in Figure 18. The additional control devices on automobiles through 1971 result in a considerably higher reduction rate in hydrocarbon emissions in the Study area.

On the basis of the results of the emission inventory and projections of hydrocarbon emissions, the following conclusions may be drawn.

1. The principal sources of hydrocarbons are gasoline-powered motor vehicles and refuse disposal by open burning.

2. A decrease in hydrocarbon emissions from motor vehicles will occur starting in 1968 as a result of exhaust controls on all new cars, as required by Federal regulations. A decrease of approximately 31 percent of the 1966 emissions by the year 1980 is expected.

3. If additional reduction in hydrocarbon emissions from motor vehicles is achieved by limiting the evaporation losses and further reducing the exhaust emissions, a decrease of almost 56 percent can be expected by 1980.

4. A considerable reduction in total hydrocarbons released to the atmosphere can be achieved by regulating the means of refuse disposal. A reduction of more than 99 percent of hydrocarbons from refuse burning will result if all open burning

is prohibited and strictly enforced and all incineration is performed in multiple-chamber incinerators.

5. Restrictions on the evaporation of gasoline from storage tanks and those on certain industrial processes will not add greatly to the overall area reduction in hydrocarbons, but may be necessary to minimize the hydrocarbon emissions in localized areas.

6. A reduction in hydrocarbon emissions in the St. Louis area is expected as a result of limiting emissions from automobiles and the implementation of regulations relating to refuse disposal. An overall decrease of approximately 23 percent by 1970 and 37 percent by 1980 can be expected.

7. The emissions of hydrocarbons are greatest in areas of high traffic densities, principally in the central business district. The actual concentration of hydrocarbons in this area has not been determined; however, available information indicates the advisability of starting to limit hydrocarbon emission in this area now. An important reduction would occur as a result of decreased traffic density if a rapid transit system that will be used by large segments of the population is developed.

8. Since not all of the hydrocarbons enter into photochemical reactions to produce smog, a precise estimate of the impact of these reductions on concentrations of total oxidant in the area is not possible at present.

9. The formulation of relationships between traffic densities, hydrocarbon and nitrogen oxide emissions, and observed concentrations of total oxidant is necessary to provide a useful guide for future transportation studies. To undertake the development of such relationships, information relating to existing and projected traffic volumes, traffic speeds, and diurnal variation in traffic are needed.

AIR-USE PLAN - CARBON MONOXIDE

Carbon monoxide is emitted primarily from motor vehicles. Consequently, the emission patterns and ambient air concentrations are closely related to the traffic patterns with respect to both time and location. If major reductions in ambient air concentrations of carbon monoxide are to be achieved, automotive emissions must be reduced. The air quality can be improved by limiting the emissions from automobiles through the installation of central equipment and by reducing the number of vehicles on the road by the development of a rapid transit system. Both of these approaches are needed to lessen the emissions of pollutants in the Study area.

Air-Quality Goals

A maximum 8-hour average concentration of 30 ppm and a 1-hour average concentration of 120 ppm have been proposed as the air-quality goals for the Study area. Although these goals are based on effects, there is some question whether the selected goal of 30 ppm is sufficiently low to meet the needs of certain population groups living in the central urban area. The effects of carbon monoxide are discussed in detail in Volume VI of this report.

Existing Concentrations

Continuous monitoring of carbon monoxide concentrations has been performed at the CAMP station in St. Louis since March 1964. During the period from March 1964 to September 1965, the average monthly concentrations varied from 5 to 10 ppm, with an overall average of approximately 6 ppm. The maximum 24-hour, 1-hour, and 5-minute average concentrations observed during this period were 17 ppm, 27 ppm, and 53 ppm, respectively, which, allowing for time-concentration relationships, are within the air-quality goals. Since these measurements represent the concentrations at only one location, this comparison of existing concentrations and air quality goals cannot be extended to include the entire city or even the entire central business district. For example, the concentrations of carbon monoxide observed at the CAMP site represent the conditions some 30 or 40 feet away from the street. Recent investigations have shown that the concentrations in vehicles are about two times the CAMP values and those in traffic are as much as four times as high as those recorded at the CAMP site. It is probable that the concentrations of carbon monoxide in the more heavily traveled parts of the central business district are higher than those observed at the CAMP station. Furthermore, one can expect much lower concentrations in areas outside of the central business district and away from major traffic arteries.

Existing and Projected Emissions

During 1963, an estimated 1,115,000 tons of carbon monoxide was emitted to the air of the St. Louis Metropolitan Area. Gasoline-powered motor vehicles accounted for approximately 98 percent of this amount.

Projections indicate that by 1980 the rate of gasoline consumption in the area will be double that of 1963. If automobile exhausts continue uncontrolled, the emissions of carbon monoxide would increase in proportion to more than 2 million tons annually in the year 1980.

The uncontrolled emissions of carbon monoxide in the exhaust gases are approximately 3.1 percent by volume under average urban operating conditions.[4] Depending on the average route speed, the rate of emission varies from approximately 6 percent by volume at 5 miles per hour to 2 percent at 60 miles per hour. The 3.1 percent by volume corresponds to an average route speed of 25 miles per hour. On the basis of the average speed in urban areas and the average daily mileage traveled, an average of 4.2 pounds of carbon monoxide is emitted daily per automobile.

Emission Reduction Plan

Federal Law S-306 authorizes the Secretary of Health, Education, and Welfare to set limitations on air pollutant emissions from automobiles. The limitations on carbon monoxide emissions have been specified as 1.5 percent by volume for all vehicles with an engine displacement in excess of 140 cubic inches. (For smaller engines a slightly higher emission rate is allowed.) These limitations will go in effect starting with the 1968 models. The overall reduction in emissions achieved by these controls, although decreasing the emissions per equipped vehicle by 50 percent, is almost negated by the expected increase in automobile travel. The net effect, as shown in Figure 20, is the maintenance of the existing emissions quantities for the next 20 years.

Assuming that emissions of carbon monoxide from motor vehicles will be controlled to 1 percent by volume, starting with the 1971 models, a reduction as shown in Figure 20 can be expected. (The State of California requires that carbon monoxide be controlled to 1 percent by volume starting with the 1970 models.) The implementation of this emission limitation would reduce overall emissions in 1980 to 20 percent below the 1963 amounts.

The curves in Figure 20 as well as the above discussion are based on the existing and projected emissions of carbon monoxide for the entire Study area. It is, however, the central business district where the traffic density and hence pollutant emissions are high and of primary concern. Before the impact of these

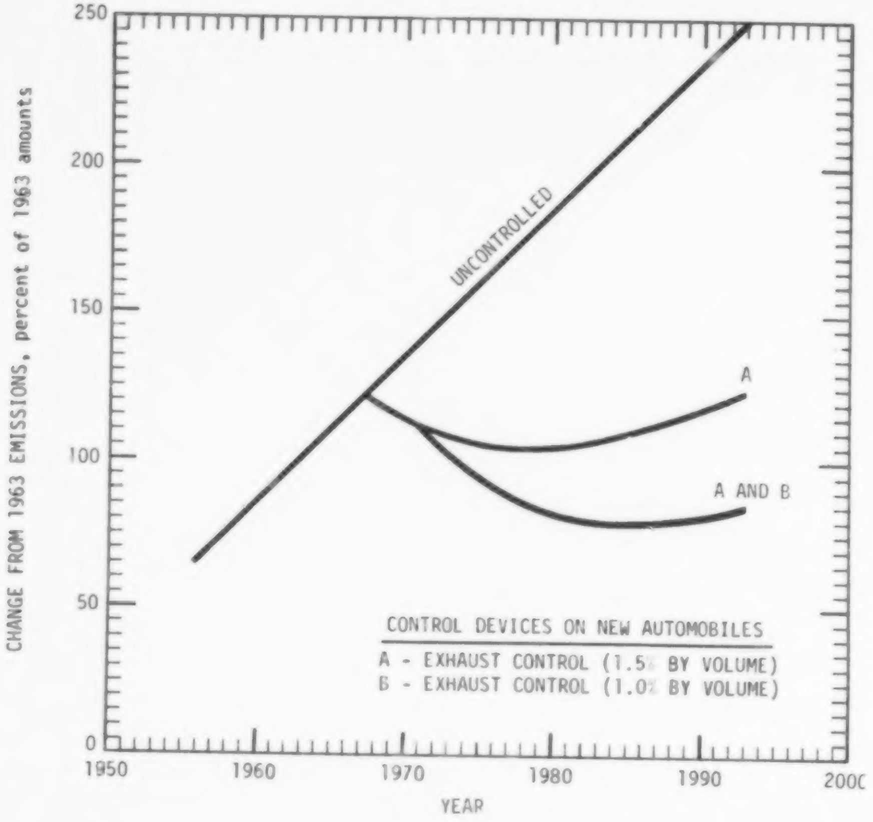


Figure 20. Projected carbon monoxide emissions from gasoline-powered motor vehicles with and without control devices.

reductions on that area can be evaluated, more detailed information on the expected increase in traffic density is needed.

AIR-USE PLAN - NITROGEN OXIDES

An air-use plan for nitrogen oxides, as such, is not included in this report. The primary reason for this omission has been the lack of air-quality measurement data and criteria, which in turn make the setting of air-quality goals for this class of pollutants impractical. Whenever the air-quality goals are prescribed, the emissions of nitrogen oxides and the resulting ambient concentrations of these pollutants will need to be evaluated in terms of these goals and, if necessary, reductions in these emissions will have to be prescribed and measures will have to be taken to achieve the reductions. As a first step in the design of an air-use plan, this report chapter relates nitrogen oxides emissions to the various types of sources, and gives estimates of future emissions.

By far the most important source of nitrogen oxides is the combustion of fuels. The ever-increasing population and the continuous urbanization of the Study area will undoubtedly result in higher energy requirements. These requirements, at least in part, will be fulfilled by increased consumption of fossil fuels, which will, unless controlled, increase the emissions of nitrogen oxides. The magnitude of increase is dependent not only on the future energy requirements, but more importantly on the types of fuels used to meet the requirements.

Existing Concentrations

Nitric oxide and nitrogen dioxide have been monitored at the St. Louis CAMP site since March 1964. The monthly mean concentrations of nitrogen dioxide during the period from March 1964 to September 1965 varied from 0.02 to 0.05 ppm. The maximum 24-hour average concentration observed during this time was 0.12 ppm, whereas the highest 1-hour average concentration during the same time period was 0.22 ppm. The frequency distribution of measurement data observed from March 1964 to February 1965 showed a geometric mean value of 0.028 ppm and a 99 percentile value of 0.091 ppm.

Comparison of the observed concentrations with the State of California air-quality standard, which is 0.25 ppm for a maximum 1-hour average concentration, shows that this air-quality goal was not exceeded at the CAMP site. The CAMP measurements cannot be used, however, as the maximum value for the St. Louis area.

Existing Emissions

During 1963, an estimated 138,300 tons of nitrogen oxides was released to the air of the Study area. In terms of their contribution to the total area emissions, the various source categories accounted for the following percentages: electric power generation, 38 percent; transportation sources, 35 percent; industrial fuel use, 16 percent; residential-commercial fuel use, 6 percent; industrial processes, 3 percent; and other sources, 2 percent. The burning of refuse material accounts for less than 1 percent of the community total.

Stationary Combustion Sources - During 1963, an estimated 85,500 tons of nitrogen oxides was emitted from the combustion of fuels in stationary sources. The combustion of coal accounted for 83 percent, natural gas for 12 percent, and fuel oil for 5 percent. During the same time period, coal supplied 57.7 percent; gas, 31.1 percent; and fuel oil, 4.2 percent of the energy requirements. These figures are based on a total heat input of 312 X 10^{12} Btu. Emission rates of nitrogen oxides according to Btu output from coal, fuel oil and gas are given in Table 21.

Table 21. EMISSION RATES OF NITROGEN OXIDES IN INTERSTATE AIR POLLUTION STUDY AREA
(Btu heat generated)

Fuel	Industrial boilers	Domestic-commercial units
Coal	1.1	0.4
Fuel Oil	0.9	0.9
Gas	0.3	0.2

Fuel Consumption - Fuel consumption for the Study area has been projected by Ridker[5] for the years 1970 to 1980 and is listed by user category in Table 22. The projections for 1980 indicate an increase above the 1963 consumption levels of

Table 22. PROJECTIONS OF FUEL CONSUMPTION IN INTERSTATE AIR POLLUTION STUDY AREA

Fuel	User category	1963	1970	1980
Coal, tons/yr	Steam-electric utilities	4,874,000	7,100,000	6,200,000
	Industry	1,628,000	1,560,000	1,530,000
	Residential	738,000	428,000	340,000
	Commercial	222,000	111,000	95,000
	Total	7,462,000	9,199,000	8,165,000
Fuel oil gal/yr	Steam-electric utilities	642,000	642,000	642,000
	Industry	114,507,000	133,000,000	145,000,000
	Residential	120,543,000	98,800,000	80,800,000
	Commercial	6,414,000	8,900,000	12,300,000
	Total	242,106,000	241,342,000	238,742,000
Gas 10^6 ft^3/yr	Steam-electric utilities	9,200	9,200	9,200
	Industry	42,550	54,500	65,000
	Residential	42,685	55,700	63,800
	Commercial	2,876	3,900	5,500
	Total	97,311	123,300	143,500

almost 47 percent in the use of gas and 9 percent in the use of coal, and a 1 percent decline in the use of fuel oil. The overall increase in the energy to be supplied by these fuels was estimated to be approximately 20 percent.

A change in fuel-use patterns is expected to accompany the increase in total energy requirements. In the case of the residential use of fuels, use of gas and electricity are projected to increase whereas coal and fuel oil consumption are expected to decline. In the industrial category, gas and fuel oil consumption are projected to increase, with the consumption of coal remaining at the present levels. Consumption of coal by the steam-electric utitities is projected to increase by 64 percent by 1970 and then decline to about 31 percent above the 1960 consumption in 1980. The decline in the use of coal between 1970 and 1980 is expected to be offset by the use of hydro and nuclear power for electrical generation.

Emissions of Nitrogen Oxides - According to the above projections, approximately 101,000 tons of nitrogen oxides will be emitted in 1980 from the combustion of fuels in stationary sources. This is 15,500 tons or 18 percent more than the 1963 emissions. The emissions from steam-electric utilities and industrial fuel use are expected to increase by 27 and 10 percent, respectively. The emissions of nitrogen oxides from residential and commercial fuel uses are, however, expected to decline by approximately 10 percent. Projected annual emission rates are summarized in Table 23 by type of fuel and user category.

Mobile Combustion Sources - During 1963, an estimated 759 million gallons of gasoline burned in the Study area resulted in an emission of 43,400 tons of nitrogen oxides. An additional 4,700 tons was emitted by aircraft, vessels, and railroads. Unless controlled, the emissions of nitrogen oxides from motor vehicles would be approximately 80,000 tons per year by 1980.

Summary - Nitrogen oxides constitute one of the five or six groups of major pollutants that orginate community-wide and are of general importance. Population growth and its related activities in urban areas have caused the emissions of these pollutants to increase, and, unless controlled, the emissions will continue to increase.

The emission of nitrogen oxides from all sources is expected to increase slightly more than 2 percent per year until 1980, when approximately 195,000 tons per year will be released in the Study area. Because of the changing fuel-use patterns, comparable increases cannot be expected in all parts of the Study area. Because of the rapid rate of increase in gasoline consumption, the emission rate of nitrogen oxides in the downtown area probably will increase considerably more than elsewhere. In contrast, emissions from residential areas are expected to decrease.

A reversal of the continually increasing nitrogen oxides emissions may be necessary, if not at the present then surely in the future. To assess the existing concentrations, sampling of the nitrogen oxides throughout the community should be initiated. Similarly, investigation of control measures for reducing emissions from mobile as well as stationary sources should be encouraged.

Table 23. PROJECTIONS OF NITROGEN OXIDE EMISSIONS IN INTERSTATE AIR POLLUTION STUDY AREA

Source category	Emissions of nitrogen oxides, tons/yr		
	1963	1970	1980
Combustion of fuels - stationary sources			
Steam-electric utilities	53,100	76,800	67,300
Coal	51,300	75,000	65,500
Fuel oil	a	a	a
Gas	1,800	1,800	1,800
Industry	23,800	24,900	26,000
Coal	16,300	15,600	15,300
Fuel oil	2,100	2,400	2,600
Gas	5,400	6,900	8,100
Commerical	900	720	800
Coal	600	300	200
Fuel oil	100	150	200
Gas	200	270	400
Residential	7,900	7,200	7,100
Coal	3,000	1,700	1,300
Fuel oil	2,000	1,700	1,400
Gas	2,900	3,800	4,400
Combustion of fuels - mobile sources	48,100	64,300	87,000
Motor vehicles	43,400	58,600	80,300
Other	4,700	5,700	6,700
Industrial process emissions	4,700	5,700	6,700
Totals	138,500	179,620	194,900

a Negligible.

Existing Conditions

Surveys conducted during portions of the Study Phase I and Phase II operations (for detailed information see Volume IV of this report) indicated that odors are a serious problem in certain portions of the Study area. The odor frequency summary for the Phase II report is presented in Figure 21. This summary shows that odors occur most frequently in the City of St. Louis and Illinois (principally in the East St. Louis area), and with a somewhat lower frequency in St. Louis County. The two most frequently detected categories of odors were combustion (auto exhausts, coal smoke, etc.) and chemical (refinery, medicinal, sulfurous, vanilla, etc.).

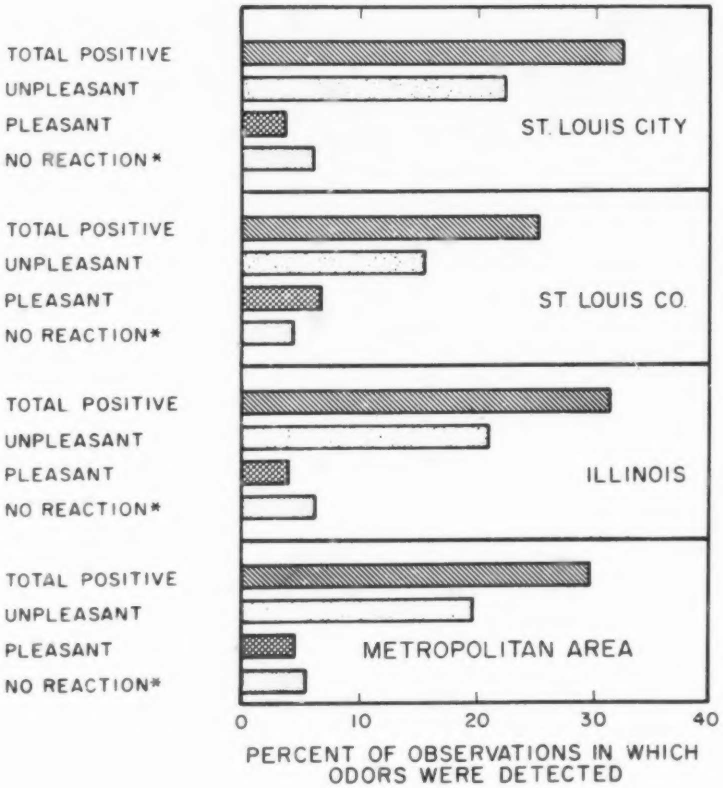


Figure 21. Odor frequency summary.

Chemical odors are of particular concern in the City of St. Louis, where they represented 28 percent of all the odors observed. These odors occur primarily in association with winds from the east-southeast to south-southeasterly directions (see Figure 22). Because of its proximity to the large chemical complexes on the east side of the Mississippi River, the downtown area of St. Louis, in particular, experiences a high frequency of chemical odors, many of which are very objectionable.

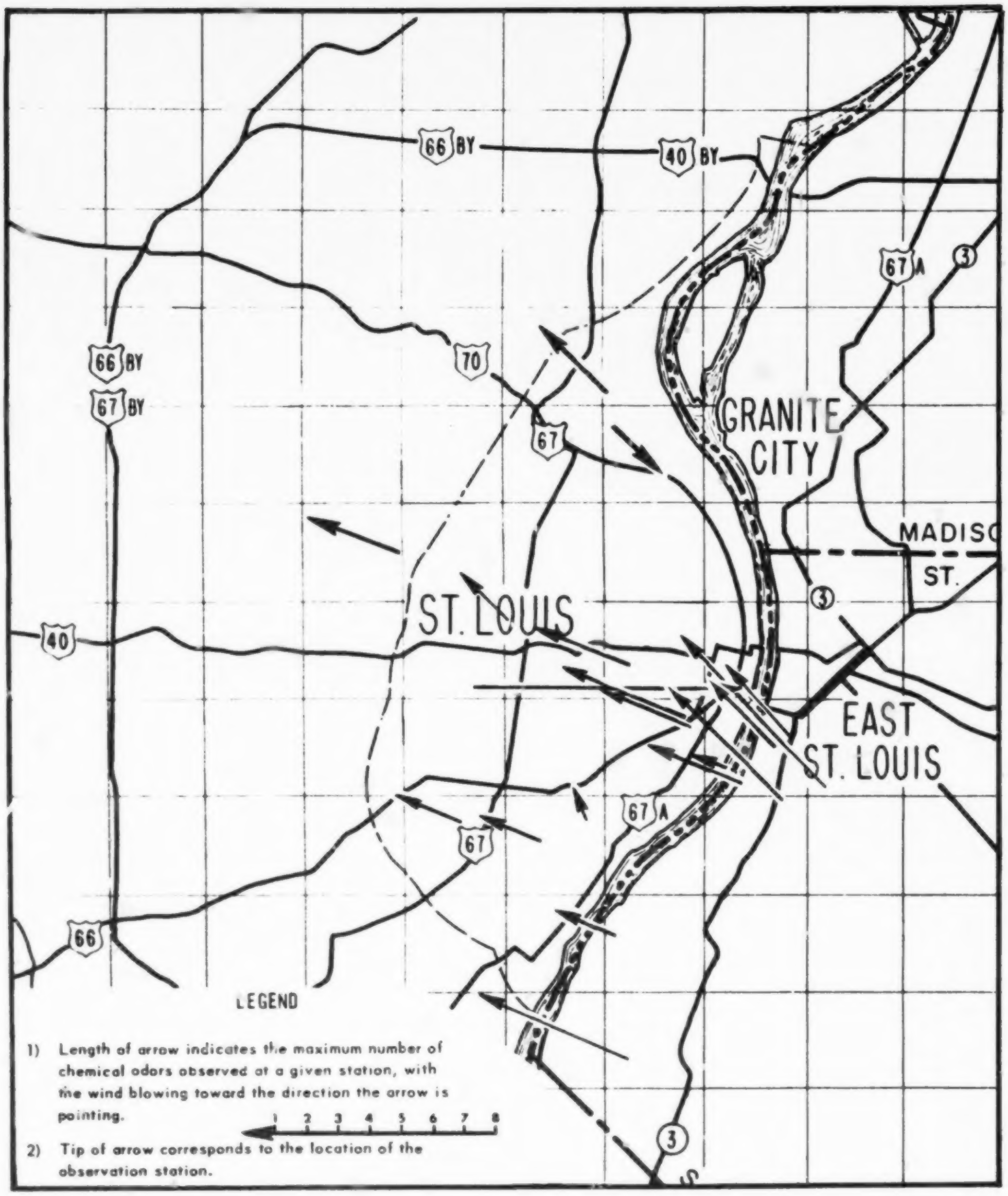

66 BY
40 BY
67 A
3
66 BY
67 BY
70
67
GRANITE CITY
MADISC
ST.
3
ST. LOUIS
40
EAST ST. LOUIS
67 A
67
66
LEGEND
1) Length of arrow indicates the maximum number of chemical odors observed at a given station, with the wind blowing toward the direction the arrow is pointing.
1 2 3 4 5 6 7 8
2) Tip of arrow corresponds to the location of the observation station.
3

Figure 22. Chemical odor observations related to wind direction.

In contrast to chemical odors, combustion and combustible waste odors were not associated with winds from a particular direction because the sources of these odors are located throughout the community.

The results of the odor surveys indicate that unpleasant odors often cover a significant portion of the metropolitan area.

Air-Quality Goals - Odors

Air-quality goals for odors pertain to "objectionable" odors. An odor is considered "objectionable" when 15 percent or more of the people exposed to it believe it to be objectionable in usual places of occupancy. The sample size needed to determine the "objectionable" quality should be at least 20 people or 75 percent of the exposed if fewer than 20 people are exposed. The goals are:

1. No odors would be permitted to occur on or immediately adjacent to properties used for residential, recreational, educational, institutional, hotel, retail sales, or other similar purposes.

2. On or immediately adjacent to industrial properties where the need for odor-free air is not so imperative, the release of pollutants would be prohibited if persons with a normal sense of smell could detect the odors after they were diluted in the ratio of one volume of odorous air to not more than 20 volumes of odor-free air.

3. In areas not included under items 1 and 2 above, the release of pollutants would be prohibited if persons with a normal sense of smell could detect the odors after they were diluted in the ratio of one volume of odorous ambient air to not more than four volumes of odor-free air.

Evaluation of Existing Conditions

The surveillance of odors throughout the entire Interstate Air Pollution Study area should be made an integral part of the developing air resource management program. This surveillance can be accomplished by surveys of the type described in Volume IV of this report and through odor observations made by both source and program personnel.

Because of their generally complex nature, the odorous pollutants released to the atmosphere can not be easily estimated quantitatively, and up to the present time the most reliable and sensitive instrument available for detecting and judging odors is the human nose. Because of this, odors must be measured and evaluated by the quite simple and satisfactory dilution technique. By using variations of this technique, measurements may be made on odorous materials obtained either from the source or from the ambient air.

For sampling at the source, a volumetric sample of the material from the stack or other appropriate portion of the process is obtained and diluted with a known volume of odor-free air. Sampling can be accomplished quite simply by means of a hypodermic syringe or other commercially available device. After the sample is obtained and diluted, a panel consisting of three or more persons sniffs the sample to determine the presence of an odor. If an odor is detected, successive dilutions are made to determine the volume ratio of odor-free air to contaminated air required to render the contaminated air mixture odor free, as determined by the panel.

The volume ratio thus determined can then be utilized in conjunction with atmospheric diffusion equations to indicate ground-level concentrations at varying distances from the source.

The use of this technique by source owners or operators to determine their individual contribution to the overall odor problem should be encouraged. The multitude of sources in the Study area would make such monitoring by govenmental program personnel entirely too burdensome. In addition, by requiring the source owners to monitor their own activities, each of them will develop a greater appreciation and understanding of the existing problem, which should serve as encouragement for the effort necessary to achieve the desired level of air-quality.

Because, among other things, the syringe technique is not adequately sensitive and is time consuming, it is not suitable for making ambient air measurements in the field. Odors in many cases are very transient and require a device that can make dilutions rapidly and reasonably accurately. Such a device,[6] called the "Scentometer," has been developed. This instrument consists of two plenum chambers for air that is to be purified, two activated-carbon filters for purifying a portion of the air, a mixing chamber, and several critical orifices through which the odorous air passes into the mixing chamber. By closing off all of the critical orifices, the operator can draw ambient air through the activated-carbon filters. After eliminating olfactory fatigue by breathing the purified air for about a minute, he can open orifices until the volume ratio obtained produces a detectable odor. This procedure is used to determine whether the ambient air-quality goals are being exceeded. Also, by using the device in conjunction with wind direction information and a map, odor sources can be located by triangulation.

Valuable information regarding existing conditions can also be obtained from citizen complaint records. A citizen's complaint form adapted to electronic data processing has recently been developed for use in the Study area. Since the data forms for the odor surveys are also adapted to this method of data handling, a rapid and up-to-date analysis of the information produced by these two sources will be possible.

Odor Reduction Plan

Priorities - On the basis of data provided by the Phase I and II odor surveys and that generated by present and future surveillance activities and complaint records, priorities for action should be established to attain an acceptable level of air-quality for the entire air pollution basin. These priorities should relate to the numbers of people, to the geographical area affected, and to the degree of objectionableness of the odor. The geographical area should be considered from a land-use standpoint. For example, an odor that affects a primarily residential area should receive a higher priority for reduction or elimination than one that affects an area used mostly for industrial purposes.

In some parts of the Study area land use is mixed, and in others residential areas border on heavy-industry areas. These areas should be treated on an individual basis, with suitable long-range plans implemented to install source controls or provide suitable separation of source and receptor. Steps leading to the achievement of the desired air-quality goals should be based initially on community understanding of the nature of the problem and subsequently on community-wide understanding of the efforts and improvements made by both government and industry.

Controls - Following the establishment of priorities, owners of the sources responsible for the emissions should be encouraged to institute and control actions. If possible, and before ordinances are enacted, cooperative agreements between the priority sources and program agencies should be entered into. By proceeding in this manner, the source operators will have an opportunity to demonstrate their good intentions, and improvements in existing conditions will occur at an earlier time than would otherwise be possible.

Planning and Zoning - Liaison with planning and zoning authorities should be developed to increase the understanding and appreciation of the odor problem, and to encourage their cooperation in obtaining suitable separation of sources and receptors.

Research - Research activities on the part of both government and industry should be encouraged, for there is much to be learned about the kinds of compounds that produce odors and their related physiological and psychological effects. Researchers should be encouraged to develop methods for measuring odorous pollutants that do not rely on the human sense of smell.

BENEFITS OF RAPID TRANSIT SYSTEM

Rapid transit has been considered as a cure for congested streets, overcrowded parking facilities, and long commuting times. It can also be a cure for certain types of air pollution. Rapid transit facilities can reduce the volume of traffic, especially in the central business district during the "rush hours," and consequently reduce the emissions of pollutants from motor vehicles. These pollutants are carbon monoxide, hydrocarbons, oxides of nitrogen, odors and oxidants (indirectly). The development of the air-pollutant-free type of rapid transit system in the St. Louis area would materially reduce the amounts of these pollutants. Construction of a rapid transit system should, therefore, be supported on the basis of its importance in reducing air pollution. Local air pollution control agencies should aid in the development of a rapid transit system by further evaluation of the air pollution aspects and participating in any discussion and decisions involved.

Large amounts of hydrocarbons, carbon monoxide, and nitrogen oxides are emitted daily from the operation of motor vehicles in the area. As noted in preceding sections, motor vehicles emit an estimated 63 percent of hydrocarbons, 98 percent of carbon monoxide, and 35 percent of nitrogen oxides of the total amounts of these pollutants emitted from all types of sources in the Study area. A large proportion of these pollutants are emitted in the central business district or along the main thoroughfares leading into the center of the city. The high traffic density in the central business district and the low average speeds of vehicles result in high emission rates. In addition to the high emission rate of pollutants, the confinement of these pollutants by the tall buildings and narrow streets results in much higher sidewalk concentrations of pollutants than elsewhere.

Emissions of carbon monoxide and hydrocarbons are expected to be reduced as a result of Federal regulations limiting the emissions of these pollutants from motor vehicles. Preliminary estimates based on CAMP data and projected traffic increases show, however, that these reductions will probably not be sufficient to maintain the desired ambient air levels of these pollutants in the downtown area.

Since reductions in emissions of nitrogen oxides from automobiles have not yet been required, the ambient air concentrations of this pollutant will undoubtedly continue to increase. A rapid transit system can assist in reducing nitrogen oxides in the downtown area by reducing the number of automobiles in the congested area.

Before any quantitative estimates of the impact of the proposed rapid transit system on the ambient air levels of pollutants can be made, it will be necessary to determine the existing emissions on a smaller area basis than has previously been done. For this purpose, information on traffic count, average speeds, and density variations is needed. With this information, the expected reductions in pollutant levels or the traffic density that will result in desirable air-quality may be determinable. The air-quality data collected in the St. Louis CAMP station, which is located in the central business district, can provide a good starting point for this investigation.

Investigations concerning various effects of motor vehicles emissions such as vegetation damage, eye irritation, and odors should also be carried out to estimate the effects of the proposed rapid transit system. With this information it may then be possible to design an air-use plan for the central business district and provide a quantitative estimate of the effect that a rapid transit system may have on the air-quality.

SUGGESTED ORGANIZATION OF INTERSTATE AIR POLLUTION STUDY AREA AIR RESOURCE MANAGEMENT PROGRAM

Previous portions of this report have presented a general air resource management program outline, specific air-quality goals, and plans designed to reach those goals. The purpose of this chapter is to outline the administrative organization needed to assure functioning of the activities envisioned by the air resource management program. In general, the organization is composed of existing governmental agencies with new or expanded functions. Major emphasis is placed on coordination of functions and assurance of decisions and action over the entire air pollution basin.

In brief, a three-level (state, regional, local) coordinated organization is proposed (Figure. 23). The first level stems from the general authority of the States of Illinois and Missouri. The second, consisting of a regional organization formed by interstate agreement, is currently being implemented by continuation of activities of the Study Project Executive Committee, with this Committee attached to the East-West Gateway Coordinating Committee. The third level pertains to the local level involving St. Louis County, which is currently covered completely by

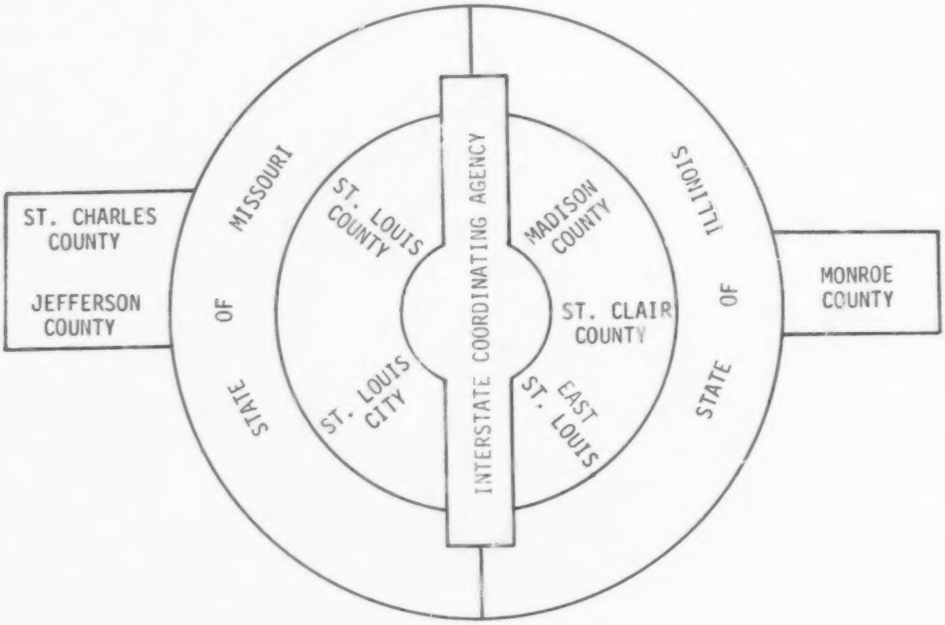

ST. CHARLES COUNTY
JEFFERSON COUNTY
STATE OF MISSOURI
ST. LOUIS COUNTY
ST. LOUIS CITY
INTERSTATE COORDINATING AGENCY
MADISON COUNTY
ST. CLAIR COUNTY
EAST ST. LOUIS
STATE OF ILLINOIS
MONROE COUNTY

Figure 23. Air resource management program organization.

a single agency - the St. Louis County Health Department; St. Louis City, currently covered completely by the Division of Air Pollution Control of the City of St. Louis; and St. Clair and Madison Counties in Illinois. These two counties contain 54 separate incorporated areas plus county jurisdictions all overlain by the jurisdiction of the Illinois Air Pollution Control Board. In terms of organization to meet the air pollution problem, this area is currently out of balance with the two major areas in Missouri.

ILLINOIS PROGRAM IN ST. CLAIR AND MADISON COUNTIES

To implement air pollution control in St. Clair and Madison Counties, it is proposed that the Illinois Air Pollution Control Board organize a regional office in that area and assign to it an adequate and competent staff. It is further proposed that the Board meet in that area to consider the problems of that area. The Board should be guided by an advisory committee representing county and municipal governments of that area.

The specific activities of the regional office should include:

1. General responsibility for air quality and regulatory action.

2. Control of major air pollutant sources, including negotiation of control plans with major sources.

3. Technical supervision of personnel hired by local government.

4. Monitoring of air quality levels.

5. Emission inventory.

6. Establishment of air-quality goals and standards.

7. Establishment of rules and regulations, including emission regulations.

8. Participation in urban planning and zoning functions to assure adequate consideration of air-quality in the planning process.

9. Program organization and administration.

The regional office of the Illinois Air Pollution Control Board, while carrying out program responsibilities in the area, should be continually alert to the interest of local groups working toward a local control effort - an effort that might eventually result in a local assumption of responsibility for air pollution control in the entire area pursuant to a certificate of exemption issued by the Illinois Board. As a step toward qualifying for exemption, the local control effort might take the form of a locally financed district operation, administered by the Board (similar in organization to those in the State of Massachusetts). The eastern parts of both counties should probably be excluded from such a district operation because of their physical seperation from the main air pollution basin. The line of separation is the bluff line bordering the American Bottoms. It is suggested, however, that the Board consider appropriate recommendations for State legislation to permit local governments to join legally for the control of air pollution.

Initially, activities of a local agency might include:

1. Solid waste collection and disposal problems including backyard burning on private premises, but excluding those involving large incinerators or disposal of wastes from entire communities.

2. Space-heating problems involving units with input of less than 1 million Btu per hour.

3. Weed control.

4. Wind-borne dust control from construction and other sites within the jurisdiction of the local agency.

5. Other problem areas or items that may be agreed to in writing between the State Air Pollution Control Board and tne local agency.

MISSOURI STATE AIR POLLUTION PROGRAM

The Missouri Air Conservation Commission would participate in any interstate agreement preparation and in any governing board provided by such an agreement. The State agency would review air-quality goals, rules, and regulations of the St. Louis area and take action to approve or disapprove them in accordance with State requirements. The State's approval authority would apply to intrastate standards and rules and regulations, and would through them apply to the State of Missouri's responsibility to the State of Illinois under the terms of the agreement. The Missouri State agency would also have the responsibility for controlling air pollution sources outside the jurisdiction of the agreement area that might have a deleterious influence on the air-quality in the Missouri portion of the air pollution basin. These would include St. Charles and Jefferson Counties in which an organizational arrangement between State and local agencies would be needed.

ILLINOIS LOCAL AGENCIES

As a general policy, there should be few air pollution control agencies at a local level. Where local ordinances are enacted, they should follow the suggested ordinance provisions in Appendix B and should be reviewed and approved by the Illinois Air Pollution Control Board. In its considerations, the Board should seek and be guided by any interstate agency created for the purpose of coordinating the efforts of all control groups. Agreement among the control groups regarding which agency is responsible for specific activities is necessary to assure that no geographical areas are missed or functional items overlooked. The general policy should be to have activities assigned to the agency that can best handle them technically.

The air resource management plan and the air-quality goals should serve as the primary basis for decisions regarding activities to be conducted by local agencies. The local agency must have authority to enforce action and the technical capability for handling the activity. Types of air pollutant source categories will usually be the basis for establishing the division of responsibility.

MISSOURI LOCAL AGENCIES

With the modifications and growth envisioned in its development plan the Division of Air Pollution Control of the city of St. Louis is organizationally satisfactory, except that the agency needs a means for coordination of its activities with those of other air pollution control agencies in the area and with those of planning agencies within their areas of jurisdiction.

St. Louis County is covered by a single air pollution control agency. which is part of the St. Louis County Health Department. This agency's immediate development plan is satisfactory. A report[7] of November 30, 1965, describes this plan. Like those of the rest of the Study area, this agency's plan for the future needs to include a means for coordination of its activities with other agencies.

INTERSTATE AGREEMENT

The Study participants recognize a need for an interstate agreement between the States of Illinois and Missouri to provide for an interstate organization to control air pollution originating in one state and affecting the other. This organization would initiate its own enforcement action only after it had provided opportunity through leadership and coordinating activities for the appropriate state and local agencies to manage the air resources and resolve the pollution problems. The interstate organization should consist of representatives of state and local control agencies and other appropriate groups from each state, and should have authority to adopt standards and regulations. It is suggested that the interstate control organization provided for in the agreement between the states be supported by equal appropriations from the two states.

As of May 1966 the States of Missouri and Illinois had not fully considered the nature of any compact or agreement between the two states. The concensus is, however, that an agreement or compact is needed, that it should provide for a continuing day-to-day operation in the St. Louis area, and that it should, from the state levels, contain elements that assure adequate action at any point needed along the boundary of the two states.

INTERSTATE COORDINATING ORGANIZATION

It is recommended that the activities of all control agencies throughout the area be coordinated through a central organization comprised of representatives of each agency. Such an interstate coordinating organization should have as its primary objective the provision of an orderly and scientifically correct approach toward the control of air pollution through an air resource management program and, as its secondary objective, the development of other aspects of metropolitan area governments. Such an organization might well be the successor agency to the Exective Committee of the Interstate Air Pollution Study.

The duties of an interstate coordinating organization should include consideration of emission standards or other regulations, which could be uniformly applied to meet air-quality goals. The recommendations of the organization would be made available to the control agencies. The organization might provide meteorological service for the area, including prediction of air pollution levels. It might provide a data-handling service for the several control agencies. The organization must have its own technical staff and provisions for adequate continuing financing.

GUIDELINES FOR FUTURE AIR RESOURCE MANAGEMENT PROGRAM ELEMENTS AND FINANCING

Previous sections of this report have considered the basic elements of air resource management programs and have developed suggested goals and air-use plans to reach those goals. An organizational plan has been suggested to provide for the development and implementation of the air resource management program. The objective of the following section is to provide orientation for the developing air resource management program by discussing each of the program elements and its major requirements separately. This discussion, supplemented by other volumes of this report, will be useful in implementing as well as developing ordinances, control practices, and plans for reduction of air pollutants.

CONTINUING AIR-QUALITY AND EFFECTS-MONITORING PROGRAM

Volumes III and IV of this report provide adequate air-quality data for implementing the air resource management program. A report of operations and proposed air-quality monitoring program plans may be found in a report of the Interstate Air Pollution Study Air-Quality Monitoring Subcommittee. Additional air-quality data are being provided by the Continuous Air-Monitoring Program of the Public Health Service and activities of the several agencies.

The immediate program need is to institute the data-handling system for assembling, interpreting, and using these new data. The air-quality monitoring program should be directed toward two major objectives. The first is the determination of long-term trends of the following:

1. Particulates. Special emphasis should be placed on determining particle size distribution and composition.

2. Sulfur oxides. Investigation should not be limited to sulfur dioxide, but should also include sulfur trioxide, sulfuric acid, and sulfate. Attention should be given to determining the chemical changes undergone by sulfur compounds in the air. The latter should be handled as a research activity by a research institution.

3. Oxidants. Special attention should be given to hydrocarbons, ozone, nitrogen oxides, and other components that relate to oxidant formation. The nitrogen oxides and end products of oxidant buildup, including such items as eye-irritating and vegetation-damaging compounds, should be given adequate research attention.

4. Aeroallergens. Collection and identification of pollens and other aeroallergens should proceed at a level in keeping with the practical application of the data. Basic research should be encouraged.

5. Odors. An odor survey should be made every 9 months. Personnel at all fire stations as well as other cooperators and the methodology developed in the Phase II Odor Survey should be employed.

6. Effects. The initial approach toward monitoring long-term effects is the complaint-recording and follow-up system placed in operation by the agencies in the air pollution basin in 1966. Detailed effects studies based on needs discovered by the system should adequately define long-term trends and at the same time assist with the solution of localized problems on a priority basis.

The second major objective of the air-quality monitoring program should be the defining of local or special problems, primarily for the purpose of improving air-quality in selected areas of the air pollution basin. The following are examples of the pollutants involved.

1. Fluorides.

2. Acid mist.

3. Cement dust.

4. Diesel exhaust.

5. Odors of a chemical nature.

6. Grain dusts.

The monitoring equipment used for this type of program should be mobile. Equipment for measuring long-term trends should be located in the same place during each sampling period.

In general the problem areas would be found by the long-term-trend program and treated on a priority basis by the activities directed toward defining local and special problems. As much as possible, source owners and operators should participate in these activities to assure understanding and corrective action. It is anticipated that many problem solutions will depend on research by universities and others. These research activities should be encouraged, but should not be used as a means of unduly delaying corrective action.

In all cases the data should be handled by computer methods, and yearly reports made. Until data handling can be taken over by a central group, it should be handled by cooperative arrangement between the several agencies involved.

CURRENT AND CONTINUING EMISSION INVENTORY

Volume II of this report provides an adequate backlog of information for initiating an air resource management program in the air pollution basin; however, the program for maintaining a current emission inventory has not been developed.

The emission inventory should be linked with registration and permit systems as well as with urban planning agency activities. The first two are regulatory in nature. The third is not, although it has a regulatory expression in zoning. With the development of both regulatory and planning agencies under way, it is not possible to indicate what the ideal relationship between the two should be. That there should be coordination is clear, and that potential advantages in addition to economics of a joint effort exist is apparent. As a start, the regulatory agency could be responsible for large sources and the planning agencies for the small numerous sources. The regulatory agencies would also be responsible for preparing guidelines and evaluating the emission inventory data.

As a result of the involvement of planning agency personnel in the Study, land-use information from Madison and St. Clair Counties is being collected on the same map grid coordinate system used by the Interstate Air Pollution Study. Attention should be given to encouraging all planning agencies in the air pollution basin to utilize this same grid coordinate system; the Illinois grid coordinate system. In those areas where its use is not feasible, agencies should collect data on grid systems that can be readily converted to the Illinois system. A basic system for collecting land-use data in a manner allowing ready computation of emission information will facilitate development and use of the air pollution prediction model. This will be true for both the daily predictions and for use of the model as a planning tool.

Planning agencies should use land-use classifications that are suitable for application of air pollutant emission factors. In other words, the land-use classifications should have air-use characteristics. For example, dwelling density should be treated on a dwelling volume basis to facilitate calculation of emissions resulting from space-heating. The area of land involved should also be recorded since this will be important in developing performance zoning standards. Land used for industrial purposes should likewise have structure volumes indicated to facilitate space-heating pollutant emission calculations. Floor space, by use type as well as land area, should be recorded to facilitate development of performance standards for zoning and development of pollutant emission factors based on floor space for certain types of industry. Traffic volumes in terms of vehicle miles should also be calculable on the basis of grid squares to facilitate emission calculations as well as to serve traffic study needs. Garbage and rubbish emission inventories based on quantities generated by the several types of land-use should be prepared using the planning activities. In addition to its use for emission inventory purposes, this information would be invaluable for the planning, development, and sound operation of garbage and rubbish storage, collection, and disposal systems.

Furthermore, planning agencies should be encouraged to develop data cards, which would allow for correlating information recorded on the basis of parcel numbers, addresses, and grid coordinates.

Although the planning agency through its normal work could be expected to obtain a large amount of necessary emission inventory data for numerous small sources, the regulatory agency would need to develop a system for maintaining an emission inventory by categories of large and relatively specialized sources. This information should be submitted by the source owners or operators themselves and be verified by the agencies by field evaluation. This arrangement would encourage consideration of wastes in the source operation itself. The information collected in this way by the regulatory agency would pertain to recognized major sources such as power plants, incinerators, dumps, other major open burning, and process emissions - starting with those that are recognized major problems in the air pollution basin and advancing as resources and program needs of the regulatory agency change.

AIR-QUALITY GOALS, STANDARDS, AND CRITERIA

Criteria will presumably be developed by other agencies or will be available as a result of research work by others. The air-quality goals will in general apply to the long-range goals of the air resource management program, and standards will be legally defined and will appear in ordinances and rules and regulations.

Responsibility as well as capability for setting and updating air-quality goals and standards must be assured. Goals and standards are related to effects; therefore, the professional talent needed to set them should include people concerned with: (1) human health, (2) animal health, (3) agriculture, (4) deterioration of materials, (5) natural resources, (6) economics, and other areas of interest. Since decisions on air pollution matters are of a similar nature to those made on other community affairs, air pollution control boards should have experts available as advisors when decisions are to be made. The decisions and the responsibility should rest with the boards and should be made in the name of the governmental entity that the boards represent. Coordination should be provided through interstate agreement and the organization provided for by that agreement.

Volume VI of this report provides suggested air-quality goals and information supporting those goals. It will assist those groups and individuals who have the responsibility for setting legal standards.

USE OF CONDITIONS INFLUENCING TRANSPORT OF AIR POLLUTANTS

Volume V of this report provides an adequate basis on which to start an air resource management program. Additional information, all of which is specific for the St. Louis area, is being developed as the result of research work on the diffusion of fluorescent particles and mathematical models based on sulfur dioxide studies made during two winter seasons (1963 - 1965). In addition, starting in 1965, the development of an air pollution potential prediction system is under way. All of these activities encourage and give considerable impetus to a program for the prediction of air-quality to be used as a tool for air pollution control activities. The prediction system should be placed in operation as soon as possible to provide news media with daily predictions and supporting news releases. Predictions will bring about voluntary suppression of pollutant emissions by source operators, either through process modification or delay of activities until more suitable times of the day, or until more suitable meteorological conditions occur. In the future, in case the air resource management program does not move swiftly enough, an air pollution warning system will need to be developed to restrict activities under certain adverse meteorological conditions. Additional use of the daily prediction system would be made by the regulatory agencies to alert inspectors and others for control action, studies, and solution of specific problems.

The long-range use of the air-quality prediction system would be as a planning tool. Its development stems from research activities completed during the Study on fluorescent particle diffusion and sulfur dioxide diffusion predictions. Use of the system should be through a joint activity of the urban planning and air pollution control agencies. It should start with an air pollutant emission inventory. Once the system is tested and computerized, data could be easily and quickly interpreted on the basis of actual or proposed land-use. In this way the impact on a given area of a proposed development of a new industrial or residential area could be determined. On this basis, logical planning decisions could be made.

As another starting measure, the regulatory agencies should calculate and report to the planning agencies on the probable impact of certain large pollutant sources on air-quality in the area. The Portage de Sioux Power Plant Analysis, which is on file with the area's regulatory agencies, is an example of the type of calculations that should be made.

AIR POLLUTION CONTROL DECISIONS BASED UPON AIR-QUALITY INFORMATION AND GOALS

Appendix B suggests ordinance provisions that will reduce emissions sufficiently to meet the air-quality goals. Justifications for these ordinance provisions have been developed throughout the several volumes of this report.

The preparation of emission reduction plans by many source owners is anticipated. After approval by the air pollution control agency, these reduction plans will undoubtedly form part of the program implementation. On major community matters such as transportation and garbage and rubbish collection and disposal, air pollution control plans will be incorporated in general plans by other branches of government, probably from guidelines prepared by the air pollution control agency.

PROGRAM FINANCING

The air resource management program should develop as a coordinated and balanced activity working toward both long-term and short-term goals. The total cost of financing such an effort cannot be predicted with certainty; however, based on the program described, the availability of resources, and the legislation required, an expenditure level goal of 50 cents per capita per year is suggested for 1970.

REFERENCES

1. Private communication. Perry, H., Director of Coal Research, U.S. Department of Interior, Bureau of Mines, Washington, D. C. April 27, 1966.

2. Private communication. Simon, J.A., geologist and Head, Coal Section, Illinois State Geologic Survey. Urbana, Illinois, February 24, 1966.

3. Landsberg, H.H., L.L. Fischman and J.L. Fisher. Resources in America's future. The Johns Hopkins Press. Baltimore, Maryland. 1963.

4. Rose, A.H. Jr. Summary report of vehicular emissions and their control. Presented at the Annual Winter Meeting of the ASME. November 7-11, 1965. Chicago, Illinois.

5. Ridker, R.G. Economic costs of air pollution, studies in measurement. In preparation.

6. Gruber, C.W., G.A. Jutze, N.A. Huey. Odor determination techniques for air pollution control. JAPCA. 10:329. August 1960.

7. The air pollution control program in St. Louis County, Missouri. St. Louis County Health Department. Clayton, Missouri. November 30, 1965.

APPENDICES

APPENDIX A - PARTICULATE LEVELS DUE TO VENICE POWER PLANT

The Venice Power Plant emits about 5,000 toms of particulates per year from stacks 225 feet tall. To estimate the effects of these emissions on the area, certain values and conditions must be assumed:

1. Effective stack height (top of plume) averages 400 feet.
2. Effective average meteorological stability is class 4.
3. Average wind speed is 9.3 mph (4.15 m/sec).

The first assumption is an approximation, based on experience. The second is based on a limited tabulation of stability frequencies, which indicates that class 4 stability occurs 54 percent of the time. The third is the average wind speed at Lambert Airport over a 10-year period.

Figure A-1 indicates the maximum ground-level concentration to be expected from any elevated source and stability combination, and the distance at which the maximum will occur.To facilitate its use it has been prepared for a unit source strength and unit wind speed. In this case, the distance is slightly over 2 miles and the indicated maximum concentration is about 5.6×10^{-6} with a dimension of per square meter resulting from the formulation of the diagram. To convert to actual values, this number must be multiplied by the source strength, 144 grams per second, and divided by the wind speed, 4.15 meters per second. The resulting maximum concentration is then $5.6 \times 10^{-6} \times 144/4.15 = 194 \times 10^{-6}$ g/m^3 or 194 μg/m^3.

One assumption made in preparing the diagram, which was intended primarily for gaseous pollutants is that total reflection of the particles takes place at the ground surface. Since particulates are more likely to remain on the ground once they contact the surface, the concentration obtained above should be reduced, possibly to as low as 97 μg/m^3.

This value, 97 μg/m^3, would be added to particulates from other sources, on the average, when the wind is in the proper direction and the receptor about 2 miles from the source. Since the maximum concentration depends upon wind speed, plume height, stability, and source strength, the value suggested here may be greatly exceeded under certain conditions, with a resulting very dirty atmosphere. For a year-round average, however, the frequencies of various wind directions must be considered. The maximum frequency of winds from a single sector (16-point divisions) is 10.8 percent of the time, from the south. When this factor is applied to the average maximum as calculated above, the average annual increase of particulates at any one point attributable to the Venice Power Plant is not over 10.5 μg/m^3, and probably about 4.5 μg/m^3 since the wind sector is considerably wider than the plume width.

GPO 805-084-4

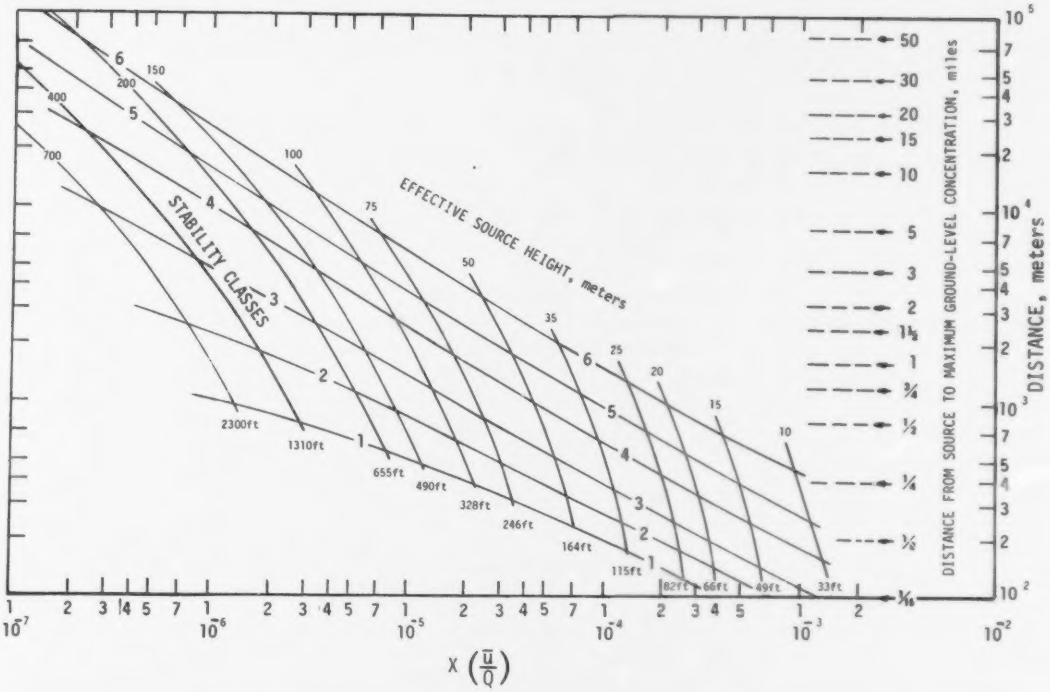


Figure A-1. Distance from source and relative value of maximum concentration for various source heights and stability classes.

APPENDIX B - SUGGESTED ORDINANCE PROVISIONS

The Interstate Air Pollution Study Phase II Project Agreement activity item number 6 provided for a subcommittee on ordinances, rules, and regulations and charged it with the task of preparing suggested ordinance provisions. The following provisions and policies designed to implement the air-use plans found in the body of this report stem from that subcommittee's work, supplemented by the active participation of all project executive committee members.

The ordinance provisions are recommended for use as guides by the several political jurisdictions in the Interstate Air Pollution Study area. Some jurisdictions have laws, ordinances, or regulations that accomplish some of the recommended provisions. Administrative procedures vary among the several jurisdictions; therefore, they are not included. For these reasons the provisions cannot be adopted without consideration of how they relate to existing legislation.

There should be as few air pollution control agencies at a local level as is consistent with efficient and effective functioning. This calls for an expansion of air pollution functions on the basis of the levels of government best suited to perform the air pollution activities.

The intent of the recommended ordinance provisions and policies is to:

1. Provide the means whereby air pollutant sources that are committed to a clean-air policy may by their own decisions determine the means of reaching the needed pollutant emission limitations.

2. Provide the means for convincing those sources not committed to a clean-air policy that such a policy is in the public interest.

3. Provide the means whereby the public, through its public agencies, can manage the air resources of the Interstate Air Pollution Study area.

4. Provide the means whereby the air-quality goals can be established as public policy.

The purposes of the recommended ordinance provisions are to (1) protect the public health, (2) provide for the protection and advancement of the public welfare, protection and enjoyment of property, and protection of business, (3) optimize the use of the air resource in the St. Louis Metropolitan Area air pollution basin, (4) provide the implementing ordinances needed to establish the air resource management program required to meet the air-quality goals listed in Table B-1, and (5) establish the emission regulations indicated as required by the air-use plan to meet the air-quality goals. The air-use plan design basis is in Table B-2.

The engineering air-use plan design is based on an urbanized area of approximately 400 square miles. The program designed to implement the engineering plan extends the area covered to include St. Louis City, St. Louis County, and the western parts of St. Clair and Madison Counties. This is the area proposed to come under the ordinance provisions in this Appendix. The other parts of the Study area come under control programs of the respective states. In Illinois, rules and regulations of the Illinois Air Pollution Control Board are being promulgated under a policy requiring a high degree of emission control. The Missouri Air Pollution Commission is expected to take similar action. The Study area is, therefore, completely provided for in the air resource management program plan.

Table B-1. SUGGESTED AIR-QUALITY GOALS FOR INTERSTATE AIR POLLUTION STUDY AREA[a]

- Sulfur oxides
  - Sulfation, measured by lead peroxide candle method
    - Maximum annual average 0.25 mg SO_3 per 100 cm^2 per day
    - Maximum month 0.5 mg SO_3 per 100 cm^2 per day

- Sulfur dioxide, measured by West-Gaeke or conductometric methods
    - Maximum annual average 0.02 ppm
    - 24-hr average 0.1 ppm not to be exceeded over 1 percent of the days in any 100-day period
    - 1-hr period not to exceed 0.20 ppm more than once in any 4 consecutive days
    - 5-min period not to exceed 0.50 ppm more than once in any 8-hr period

  - Suspended sulfate, measured by high-volume sampler
    - Maximum annual average not to exceed 4 µg per m^3
    - Not to exceed 12 ug per m^3 over 1 percent of time

  - Sulfuric acid
    - Maximum annual average not to exceed 4 µg per m^3
    - Not to exceed 12 µg per m^3 over 1 percent of time
    - Not to exceed 30 ug per m^3 hourly average over 1 percent of time

- Hydrogen sulfide, measured by AISI spot sampler using lead acetate impregnated paper
  - 0.05 ppm 1/2-hr average not to be exceeded over 2 times per yr
  - 0.03 ppm 1/2-hr average not to be exceeded over 2 times in any 5-consecutive-day period

- Oxidant (total), measured by potassium iodide colorimetric method
  - 0.15 ppm for 1 hr (not to be exceeded)

- Carbon monoxide, measured by nondispersive infrared method of measurement
  - 30 ppm for 8 hr
  - 120 ppm for 1 hr

- Dustfall, measured by settled particulate accumulated in dry jars for 1 mo
  - 10 tons per mi^2 per mo, 3-mo average above background in all areas except those zoned heavy industrial
  - (Use 5 tons per mi^2 per mo background)
  - 25 tons per mi^2 per mo, 3-mo average above background in zoned heavy industrial areas
  - (Use 5 tons per mi^2 per mo background)

- Suspended particulate, measured by high-volume sampler
  - 75 ug per m^3 annual geometric mean
  - 200 ug per m^3, annual 99th percentile

Table B-1. (Cont.)

Soiling index, measured by AISI spot sampler
0.4 Coh per 1,000 lineal ft, annual geometric mean

---

[a] Abbreviations defined

mg = milligram
cm = centimeters
ppm = parts per million
hr = hour
mo = month
μg = microgram
m = meter
mi = mile
ft = feet
Coh = function of optical density - see reference 1

Note: All goals, unless otherwise stated, apply to any place where people live or an undersirable effect could result from levels above the goal.

TABLE B-2. AIR-USE PLAN DESIGN PARAMETERS

Land-use category	Particulates, tons/mi^2/yr	Sulfur oxides, tons/mi^2/3 mo
Industrial	600	550
Commerical	175	250
Residential	130	100
Open space[a]	100	235
Air-pollution-basin average	175	300

[a] Roads, parks, playgrounds, cemeteries, vacant.

Regulation I. DEFINITIONS

A. As used in the air pollution regulations of (jurisdiction), except as otherwise specifically provided in such regulations and except where the context indicates otherwise, the following words shall have the meaning ascribed to them in this regulation:

1. Air contaminant: Any smoke, soot, fly ash, dust, cinders, dirt, fumes, gases, vapors, liquids, particulate matter, or odorous matter.

2. Air pollution: (The definition of air pollution should be consistent with the respective state law.)

Illinois: "Air Pollution" is presence in the outdoor atmosphere of one or more air contaminants in sufficient quantities and of such characteristics and duration as to be injurious to human, plant or animal life or to property, or which unreasonably interfere with the enjoyment of life and property.

Missouri: "Air Pollution", the presence in the ambient air of one or more air contaminants in quantities of characteristics and of a duration which directly and proximately cause or contribute to injury to human, plant, or animal life or health or to property or which unreasonably interfere with the enjoyment of life or use of property.

3. Approved source: A source of fuel that has had its fuel tested according to procedures specified by the (head of the air pollution control agency) and whose name appears on the approved source list.

4. Existing: Things, such as equipment, machines, devices, articles, contrivances, or installations which are in being at a stated time except that any such existing equipment, machine, device, article, contrivance, or installation which is altered, repaired or rebuilt at a cost of 30 percent or more of its replacement cost shall be reclassified as "new", as defined in this regulation.

5. New: Things, such as equipment, machines, devices, articles, contrivances or installations built or installed on or after a stated time.

6. Multiple chamber incinerator: Any article, machine, equipment, contrivance, structure or part of a structure, used to dispose of combustible refuse by burning, consisting of three or more refractory lined combustion furnaces in series, physically separated by refractory walls, interconnected by gas passage ports or ducts and employing adequate design parameters necessary for maximum combustion of the material to be burned. The refractories shall have a Pyrometric Cone Equivalent of 31, tested according to the method described in the American Society for Testing Materials, Method C-24-56.

7. Open burning: The burning of any matter in such manner that the products of combustion resulting from the burning are emitted directly into the open atmosphere without passing through a stack, duct, or chimney.

8. Particulate matter: Any material, except uncombined water, which exists in a finely divided form as a liquid or solid at "standard conditions."

9. Person: Any individual, firm, public or private corporation, association, business trust, company, partnership, contractor, supplier, installer, user, operator or owner, or any political subdivision or employee thereof.

10. Process weight: The total weight of all materials introduced into a "source operation," including solid fuels, but excluding liquids and gases used solely as fuels, and excluding air introduced for purposes of combustion.

11. Refuse: Any combustible waste material containing carbon in a free or combined state, other than liquids or gases.

12. Salvage operation: Any business, trade, industry or other activity conducted in whole or in part for the purpose of salvaging or reclaiming any product or material such as metals or chemicals.

13. Smoke: Small gas-borne particles resulting from combustion, consisting of carbon, ash, and other material.

14. Source operation: The last operation preceding the emission of an air contaminant which operation (a) results in the separation of the air contaminant from the process materials or in the conversion of the process materials into air contaminants, as in the case of combustion fuel; and (b) is not an air pollution abatement operation.

15. Standard conditions: A gas temperature of 60 degrees Fahrenheit and a gas pressure of 14.7 pounds per square inch absolute.

16. Trade waste: Solid, liquid or gaseous material resulting from construction; the prosecution of any business, trade or industry; or any demolition operation including, but not limited to, plastics, cartons, grease, oil, chemicals and cinders.

Regulation II. MAXIMUM ALLOWABLE EMISSION OF PARTICULATE MATTER FROM FUEL-BURNING EQUIPMENT USED FOR INDIRECT HEATING

A. General Provisions

1. This regulation applies to installations in which fuel is burned for the primary purpose of producing steam; hot water; hot air or other liquids, gases or solids and, in the course of doing so, the products of combustion do not come into direct contact with process materials. Fuels include those such as coal, coke, lignite, coke breeze,

fuel oil, and wood but do not include refuse. When any products or by-products of a manufacturing process are burned for the same purpose or in conjunction with any fuel, the same maximum emission limitations shall apply.

2. For purposes of this regulation, the heat input shall be the aggregate heat content of all fuels whose products of combustion pass through a stack or chimney. The heat input value used shall be the equipment manufacturer's or designer's guaranteed maximum input, whichever is greater. If two or more fuel-burning units are connected to a single stack or chimney, the total heat input of all fuel burning units connected to the stack or chimney shall be the heat input value used for the purpose of computing the maximum allowable amount of particulate matter which may be emitted. If a single fuel-burning unit is connected to two or more stacks or chimneys, the heat input of the fuel-burning unit shall be used for the purpose of computing the maximum allowable amount of particulate matter which may be emitted.

B. Provisions Applicable to Existing Fuel-Burning Equipment

1. No person shall cause or permit the emission of particulate matter, caused by combustion of fuel in existing fuel-burning equipment, from any stack or chimney in excess of the quantity set forth in the following table, except as provided in Section C of this regulation:

Heat input millions of British thermal units per hour	Maximum allowable emission of particulate matter in pounds per hour per million British thermal units of heat input
10 or less	0.60
50	0.46
100	0.41
500	0.32
1,000	0.29
2,500	0.25
5,000	0.225
7,500	0.210
10,000 or more	0.20

2. For heat inputs between any two consecutive heat inputs in the tables in this regulation, the maximum allowable particulate matter emission shall be determined by graphical interpolation on logarithmic graph paper.

3. The amount of particulate matter emitted shall be measured according to the American Society of Mechanical Engineers "Power Test Codes - PTC-27," dated 1957, and entitled, "Determining Dust Concentration in a Gas Stream." This publication is hereby made a part of this regulation by reference or other method as approved by the (Title of head of the air pollution agency).

4. The heat content of coal shall be determined according to American Society for Testing Materials D-271-64, Standard Methods of Laboratory Sampling and Analysis of Coal and Coke, D-2015-62T, Tentative Method of Test for Gross Calorific Value of Solid Fuel by the Adiabatic Bomb Calorimeter, or equivalent methods in future revisions of these standards.

C. Provisions Applicable Only to Spreader-Stoker-Fired Coal-Burning Equipment

1. The provisions of section B of this regulation shall not apply to spreader-stoker-fired coal-burning plants except as provided in this section. No person shall cause or permit the emission of particulate matter caused by combustion of coal in existing or new spreader-stoker-fired installations from any stack or chimney in excess of the quantity set forth in the following table:

Heat input in millions of British thermal units per hour	Maximum allowable emission of particulate matter in pounds per hour per million British thermal units of heat input
10 or less	1.0
50	0.76
100	0.67
200	0.59
300	0.55
400	0.53
500	0.50
larger than 500	Same as other equipment as set forth in section B of this regulation

Regulation III. USE OF FUEL IN HAND-FIRED EQUIPMENT PROHIBITED

A. General

1. This regulation shall apply to any fuel-burning equipment in which fuel is manually introduced directly into the combustion chamber, including, but not limited to, heating and cooking stoves and hot water heaters. It shall not apply to wood-burning fireplaces, wood-burning heating stoves in dwellings, fires used for recreational purposes, nor to fires used solely for the preparation of food by barbecuing.

B. Prohibition

1. On and after the dates specified in the following schedule, it shall be unlawful to operate any hand-fired fuel-burning equipment.

Approximate geographical boundary enclosed by a circular area, centered at the centerline of Eads Bridge	Date on and after which said hand-fired fuel-burning equipment shall not be used	
3-mile radius	3 years	After passage of the ordinance
7-mile radius	3 years	
All other parts of the city of St. Louis and St. Louis County and areas of St. Clair and Madison Counties west of a line 1-mile north and east of State Route 159 and following the eastern boundaries of townships covering the bluff line to the south boundary of St. Clair County.	4 years	

2. The (Title of head of the air pollution control agency) shall select and publish specific boundaries of areas provided for in subsection B (1), in general consonance therewith.

3. The (Head of the air pollution control agency) may order that any hand-fired fuel-burning equipment not be used at any time earlier than the schedule in section B (1) whenever such equipment has been found in violation of any air contaminant emission regulation on three or more occasions in any 6 months.

4. The (Head of the air pollution control agency) may order that hand-fired fuel-burning equipment be sealed (or removed from any building) when it is found that such equipment is being used subsequent to the dates given in the schedule in subsection B (1).

5. The prohibitions of the use of hand-fired fuel-burning equipment provided for in this regulation shall not apply to any installation when it can be shown beyond reasonable doubt that the building in which such installation is located will be demolished prior to 6 years after this regulation is put into effect.

Regulation IV. RESTRICTION OF EMISSION OF PARTICULATE MATTER FROM INDUSTRIAL PROCESSES

A. General Provisions

1. This regulation applies to any operation, process, or activity from which particulate is emitted except (a) the burning of fuel for indirect heating in which the products of combustion do not come into direct contact with process materials, (b) the burning of refuse, and (c) the processing of salvable material by burning.

2. For purposes of this regulation, particulate matter is any material, except uncombined water, that exists in a finely divided form as a liquid or solid at 60 degrees Fahrenheit and a gas pressure of 14.7 pounds per square inch absolute.

3. Process weight per hour is the total weight of all materials introduced into any specific process that may cause any discharge of particulate matter. Solid fuels charged will be considered as part of the process weight, but liquid and gaseous fuels and combustion air will not. For a cyclical or batch operation, the process weight per hour will be derived by dividing the total process weight by the number of hours in one complete operation from the beginning of any given process to the completion thereof, excluding any time during which the equipment is idle. For a continuous operation, the process weight per hour will be derived by dividing the process weight for a typical period of time.

4. Emission tests relating to this regulation shall be made following the standards in The American Society of Mechanical Engineers "Power Test Codes 11 - PTC-27," dated 1957, and entitled, "Determining Dust Concentration in a Gas Stream."

B. Emission Limitations

1. Except as provided for in section B (2), no person shall cause, suffer, allow, or permit the emission of particulate matter in any 1 hour from any source in excess of the amount shown in Table B-3 for the process weight allocated to such source.

2. The limitations established by section B (1) shall not require the reduction of particulate matter concentration, based on the source gas volume, below the concentration specified in Table B-4 for such volume; provided that, for the purposes of this section, the person responsible for the emission may elect to substitute a volume determined according to the provisions of section B (3); and provided that the burden of showing the source gas volume or other volume substituted therefor, including all the factors that determine such volume and the methods of determining and computing such volume, shall be on the person seeking to comply with the provisions of this section B (2).

Table B-3. ALLOWABLE RATE OF EMISSION BASED ON PROCESS WEIGHT RATE

Process weight rate,		Rate of emission,	Process weight rate,		Rate of emission,
lb/hr	tons/hr	lb/hr	lb/hr	tons/hr	lb/hr
100	0.05	0.551	16,000	8.00	16.5
200	0.10	0.877	18,000	9.00	17.9
400	0.20	1.40	20,000	10.	19.2
600	0.30	1.83	30,000	15.	25.2
800	0.40	2.22	40,000	20.	30.5
1,000	0.50	2.58	50,000	25.	35.4
1,500	0.75	3.38	60,000	30.	40.0
2,000	1.00	4.10	70,000	35.	41.3
2,500	1.25	4.76	80,000	40.	42.5
3,000	1.50	5.38	90,000	45.	43.6
3,500	1.75	5.96	100,000	50.	44.6
4,000	2.00	6.52	120,000	60.	46.3
5,000	2.50	7.58	140,000	70.	47.8
6,000	3.00	8.56	160,000	80.	49.0
7,000	3.50	9.49	200,000	100.	51.2
8,000	4.00	10.4	1,000,000	500.	69.0
9,000	4.50	11.2	2,000,000	1,000.	77.6
10,000	5.00	12.0	6,000,000	3,000.	92.7
12,000	6.00	13.6			

Table B-4. MINIMUM CONCENTRATIONS TO BE REQUIRED

Source gas volume, scfm	Concentration, grains/scf	Source gas volume, scfm	Concentration, grains/scf
7,000 or less	0.100	140,000	0.038
8,000	0.096	160,000	0.036
9,000	0.092	180,000	0.035
10,000	0.089	200,000	0.034
20,000	0.071	300,000	0.030
30,000	0.062	400,000	0.027
40,000	0.057	500,000	0.025
50,000	0.053	600,000	0.024
60,000	0.050	800,000	0.021
80,000	0.045	1,000,000 or more	0.020
100,000	0.042		
120,000	0.040		

3. Any volume of gases passing through and leaving an air pollution abatement operation may be substituted for the source gas volume of the source operation served by such air pollution abatement operation, for the purposes of section B (2), provided such air pollution abatement operation emits no more than 40 percent of the weight of particulate matter entering thereto; and provided that such substituted volume shall be corrected to standard conditions and to a moisture content no greater than that of any gas stream entering such air pollution abatement operation.

Regulation V. REFUSE NOT TO BE BURNED IN FUEL-BURNING PLANTS

No person shall burn or cause or permit the burning of refuse in any installation designed for the primary purpose of burning fuel.

Regulation VI. OPEN-BURNING RESTRICTIONS

A. Refuse Burning Restrictions

1. No person shall dispose of refuse by open burning, or cause, suffer, allow, or permit open burning of refuse.

2. In areas where no public or commercial refuse collection service is available by the effective date of this regulation, the open burning of refuse on residential premises or of refuse originating in dwelling units on the same premises shall not be in violation of this regulation until such refuse collection service becomes available or until 3 years from the effective date of this regulation, whichever is sooner.

3. Regardless of provisions of subsections A (1) and A (2) of this regulation, open burning of refuse on residential premises of refuse originating in dwelling units on the same premises shall not be a violation of this regulation in areas of low population density. The (Head of the air pollution control agency), after consultation with public agencies concerned with refuse collection and disposal, shall select and publish the specific boundaries of areas in which such open burning of refuse will not be in voilation of this regulation. In selecting such areas, he shall use a density of 100 dwelling units or less per square mile as an approximate definition of areas of low population density and he shall give due consideration to the desirability of having restrictive air pollution control regulations within the conterminous area comprising the St. Louis metropolitan area air pollution basin. The (Head of the air pollution control agency) shall select and publish revised boundaries, as described above, from time to time as population density changes.

4. Any open burning of refuse permitted by subsection A (2) or A (3) of this regulation shall be permitted only between the hours of 10:00 a.m. and 4:00 p.m.

B. Prohibition of Salvage Operations by Open Burning

No person shall conduct or cause or permit the conduct of a salvage operation by open burning.

C. Restrictions on Open-Burning of Trade Wastes

1. No person shall cause or permit the disposal of trade wastes by open-burning, except as provided in subsection C (2) of this regulation.

2. The open-burning of trade wastes may be permitted when it can be shown by a person that such open-burning is absolutely necessary and in the public interest. Any person intending to engage in open-burning of trade wastes shall file a request to do so with the (Head of the air pollution control agency). The application shall state the following:

   a. The name, address and telephone number of the person submitted the application.

   b. The type of business or activity involved.

   c. A description of the proposed equipment and operating practices; the type, quantity, and composition of trade wastes to be burned; and the expected composition and amount of air contaminants to be released to the atmosphere.

   d. The schedule of burning operations.

   e. The exact location where open-burning will be used to dispose of trade waste.

   f. Reasons why no method other than open-burning can be used for disposal of trade waste.

g. Evidence that the proposed open-burning has been approved by any fire department which may have jurisdiction. Upon approval of the application by the (Head of the air pollution control agency), the person may proceed with the operation without being in voilation of subsection C (1).

D. Restrictions on Open-Burning of Agricultural Wastes

1. The burning of plant life is prohibited. Provided that the open-burning of plant life grown on the premises in the course of any agricultural operation may be permitted when it can be shown that such open-burning is necessary and that no fire hazard will occur. Any person intending to dispose of plant life by open-burning shall file a request to do so with the (Head of the air pollution control agency) on forms provided by him. Such form may require the provision of such information as the (Head of the air pollution control agency) may reasonably need to determine the air pollution aspects of the situation and whether the request should be granted. The applicant shall furnish the (Head of the air pollution control agency) evidence that the proposed open-burning has been approved by any fire department which may have jurisdiction. Upon approval of the application by the (Head of the air pollution control agency) the person may proceed with the operation without being in violation of this subsection D (1).

2. Any open-burning permitted under provisions of subsection D (1) of this regulation shall be permitted only between the hours of 10:00 a.m. and 4:00 p.m. and only at times when the actual or forecast surface wind speed, as given by the local U.S. Weather Bureau, is 5 miles per hour or greater.

E. Restriction on Open-Burning of Tree Leaves

1. The open-burning of tree leaves in such manner as to cause nuisance, detriment, or annoyance to any person or the public is prohibited.

2. The open-burning of leaves is prohibited except between the hours of 10:00 a.m. and 4:00 p.m.

3. All open-burning of leaves shall be prohibited (5 years after this ordinance provision is put into effect) except in areas of low population density. Such areas of low population density shall be specified by the (Head of the air pollution agency) in the same manner as described in subsection A (3) of this regulation.

NOTES CONCERNING SECTION A AND E OF ORDINANCE PROVISION VI

1. The City of St. Louis will not need subsections A (2), A (3), and A (4).

2. In St. Louis County, all of sections A and E should be adopted; however, provision should be made to ensure that political subdivisions smaller than the county are still permitted to adopt and enforce ordinances and regulations restricting open-burning of leaves and refuse, which are consistent with the county regulation. These smaller political subdivisions should be encouraged to do so. However,

the county should adopt the regulations to provide for action in unincorporated areas and in areas where smaller political subdivisions fail to act.

3. In Illinois, the same principles apply to State regulations applicable in Madison and St. Clair Counties, as stated above for St. Louis County. In some respects, this is at variance with an existing State regulation. The matter will have to be considered by the Illinois Air Pollution Control Board.

Regulation VII. INCINERATORS

A. General Provisions

1. This regulation shall apply to any incinerator used to dispose of refuse or other wastes by burning and the processing of salvable material by burning. Notwithstanding definitions in other regulations, as used in this regulation the word refuse includes garbage, rubbish, trade wastes, leaves, salvable material, agricultural wastes, and other wastes. The word incinerator, as used in this regulation, includes incinerators and other devices, structures, or contrivances used to burn refuse (as defined herein) or to process refuse by burning.

2. The burning capacity of an incinerator shall be the manufacturer's or designer's guaranteed maximum rate or such other rate as may be determined by the (Head of the air pollution control agency) in accordance with good engineering practices. In case of conflict, the determination made by the Director of the air pollution control agency shall govern.

3. The amount of particulate matter emitted from any incinerator shall be determined according to the American Society of Mechanical Engineers "Power Test Codes - PCT 27," dated 1957 and entitled "Determining Dust Concentration in a Gas Stream." This publication is hereby made a part of this regulation by reference. In calculating the amount of particulate matter in stack gas, the loading shall be adjusted to 12 percent carbon dioxide in the stack gas. The carbon dioxide produced by burning of any liquid or gaseous fuel in the incinerator shall be excluded from the calculation to 12 percent dioxide. Emissions shall be measured when the incinerator is operating at its maximum capacity or at any other burning rate during which emission of particulate matter is greater, when expressed as grains per standard dry cubic foot of stack gas.

B. Provisions Applicable to Existing Incinerators

1. No person shall cause or permit the emission of particulate matter from the stack or chimney of any existing incinerator in excess of the following:

   a. Incinerators with a maximum refuse burning capacity of 200 or more pounds per hour, 0.2 grain of particulate matter per standard dry cubic foot of exhaust gas.

b. All other incinerators, 0.3 grain of particulate matter per standard dry cubic foot of exhaust gas.

2. No existing incinerator shall be used for the burning of refuse unless such incinerator is a multiple-chamber incinerator. Existing incinerators which are not multiple chamber incinerators may be altered, modified, or rebuilt as may be necessary to meet this requirement. The (Head of the air pollution control agency) may approve any other alteration or modification to an existing incinerator if such be found by him to be equally effective for the purpose of air pollution control as a modification or alteration which would result in a multiple-chamber incinerator.

3. The provisions of subsections B (1) and B (2) of this regulation shall not apply to any incinerator on residential premises used to burn refuse arising from domestic activities on the same premises in areas of low population density. The (Head of the air pollution control agency) shall select and publish the specific boundaries of areas in which subsections B (1) and B (2) of this regulation do not apply. In selecting such areas, he shall use a density of 100 dwelling units or less per square mile as an approximate definition of areas of low population density and he shall also give due consideration to the desirability of having restrictive air pollution control regulations within the coterminous area comprising the St. Louis metropolitan area air pollution basin. The (Head of the air pollution control agency) shall select and publish revised boundaries, in the manner described in the foregoing, from time to time as population density changes.

C. Provisions Applicable to New Incinerators

1. All new incinerators shall be multiple chamber incinerators, provided that the (Head of the air pollution control agency) may approve any other kind of incinerator if he finds in advance of construction or installation that such other kind of incinerator is equally effective for purposes of air pollution control as an approved multiple-chamber incinerator.

2. No person shall cause or permit the emission of particulate matter from the stack or chimney of any new incinerator in excess of the limitations prescribed in subsection B (1) of this regulation.

D. Permitted Hours of Operation

No person shall operate or cause or permit the operation of any incinerator at any time other than between the hours of 10:00 a.m. and 4:00 p.m. This restriction shall not apply to incinerators having a refuse burning capacity of five tons per hour or more.

Note: A time schedule for compliance will need be incorporated in section B (2). It is suggested that large incinerators be controlled first and smaller ones later, perhaps on the following schedule:

2000 pounds per hour and larger	12 months
1000 - 1999 pounds per hour	18 months
500 - 999 pounds per hour	24 months
All	30 months

Regulation VIII. RESTRICTION OF EMISSION OF VISIBLE AIR CONTAMINANTS

A. Restrictions Applicable to Existing Installations

1. No person shall discharge into the atmosphere from any single source of emission whatsoever any air contaminant of a shade or density equal to or darker than that designated as No. 2 on the Ringelmann Chart, or

2. Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subsection A (1) of this regulation, exclusive of water vapor.

3. This section shall not apply to existing incinerators.

B. Restrictions Applicable to New Installations and All Incinerators

1. No person shall discharge into the atmosphere from any single source of emission whatsoever any air contaminant of a shade or density equal to or darker than that designated as No. 1 on the Ringelmann Chart, or

2. Of such opacity as to obscure an observer's view to a degree equal to or greater than does smoke described in subsection B (1) of this regulation.

C. Exceptions

1. A person may discharge into the atmosphere from any single source of emission for a period or periods aggregating not more than six minutes in any sixty minutes air contaminants of a shade or density not darker than No. 2 on the Ringelmann Chart.

2. Of such opacity as to obscure an observer's view to a degree not greater than does smoke described in subsection C (1) of this regulation.

3. Where the presence of uncombined water is the only reason for failure of an emission to meet the requirements of section "A" or "B" of this regulation, such sections shall not apply.

4. The provisions of section A of this regulation shall not apply to the following, however the most modern and effective concepts and practices shall be applied to the control of pollutants.

   a. Transfer of molten metals

   b. Emissions from transfer ladles

   c. Coke ovens when pushing coke from oven

   d. Water quenching of coke on discharge from ovens

D. Method of Measurement

1. The Ringelmann Chart published and described in the U.S. Bureau of Mines Information Circular 7718 or the U.S. Public Health Service Smoke Inspection Guide as described in the Federal Register, Title 42, Chapter 1, Subchapter F, Part 75 shall be used in grading the shade or opacity of visible air contaminant emissions. The (Head of the air pollution control agency) may specify other means of measurement which give comparable results or results of greater accuracy. The two publications described in this subsection are hereby made a part of this regulation by reference.

Regulation IX. PREVENTING PARTICULATE MATTER FROM BECOMING AIR-BORNE

A. No person shall cause or permit the handling or transporting or storage of any material in a manner which allows or may allow unnecessary amounts of particulate matter to become air-borne.

B. No person shall cause or permit a building or its appurtenances or a road, or a driveway, or an open area to be constructed, used, repaired or demolished without applying all such reasonable measures as may be required to prevent particulate matter from becoming air-borne. The (Head of the air pollution control agency) may require such reasonable measures as may be necessary to prevent particulate matter from becoming air-borne including but not limited to paving or frequent cleaning of roads, driveways and parking lots; application of dust-free surfaces; application of water; and the planting and maintenance of vegetative ground cover.

Regulation X. RESTRICTION OF EMISSIONS OF SULFUR DIOXIDE FROM USE OF FUEL

A. General Provisions

1. This regulation shall apply to any installation in which fuel is burned and in which the sulfur dioxide emission is largely due to the content of the fuel burned, and in which the fuel is burned primarily to produce heat.

2. For purposes of this regulation, a fuel-burning installation is any single fuel-burning furnace or boiler or other unit, device, or contrivance in which fuel is burned or any grouping of two or more such furnaces or boilers or other units, devices, or contrivances on the same premises or otherwise located in close proximity to each other and under control of the same person. The capacity of such installations shall be the manufacturer's or designer's guaranteed maximum heat input rate.

3. The method for determining the percent of sulfur in coal shall be that described in ASTM D-271-64, Standard Methods of Laboratory Sampling and Analysis of Coal and Coke or equivalent method approved by the (Head of the air pollution control

agency). The method for determining the heat content of coal shall be described in ASTM D-271-64, Standard Methods of Laboratory Sampling and Analysis of Coal and Coke or D-2015-62T, Tentative Method of Test for Gross Calorific Value of Solid Fuel by the Adiabatic Bomb Calorimeter. All coal analyses and heat contents are to be made on a dry basis.

Moisture content of coal is to be determined in all cases and results reduced to facilitate calculations of actual pollutants. The method for determining the sulfur content of fuel oil shall be that described in ASTM D-129-64 Standard Method of Test for Sulfur in Petroleum Products by the Bomb Method.

The method for determining the heat content of fuel oil shall be that described in ASTM D-240-64 Standard Method of Test for Heat of Combustion of Liquids by Bomb Calorimeter or other method giving comparable results.

The testing methods specified in this subsection A (3) are hereby made a part of this regulation, by reference. A certified copy of each is on file in the office of the (Head of the air pollution control agency).

4. The (Head of the air pollution control agency) is authorized to take samples of any fuel by any appropriate means for the sampling of the quantity which he finds, at any reasonable time or place, for purposes of determining compliance with this regulation. Where applicable, the following methods will be used.

For coal:	ASTM: D-492-48(1958), Standard Method of Sampling Coals Classified According to Ash Content
	ASTM: D-2013-65T, Tentative Method of Preparing Coal Samples for Analysis
	ASTM: D-2234-65T, Tentative Method for Mechanical Sampling of Coal
For oil:	ASTM: D-270-65, Standard Method of Sampling Petroleum and Petroleum Products

B. Restrictions Applicable to Fuel-Burning Installations With a Capacity of 2,000 Million or More British Thermal Units Per Hour

1. After acceptable technology has been developed, no person shall cause or permit the emission of sulfur dioxide to the atmosphere from any fuel-burning installation with a capacity of 2,000 million or more British thermal units per hour in an amount greater than 2.3 pounds of sulfur dioxide per million British thermal units of heat input to the installation.

2. After acceptable technology has been developed, no person shall burn or permit the burning in any fuel-burning installation with a capacity of 2,000 million or more British thermal units per hour of any coal containing more than 1.4 percent sulfur (analyzed on a dry basis but calculated to include normal moisture) or of any oil

containing more than 2.0 percent sulfur unless it is shown by a person desiring to burn a fuel containing a higher percentage of sulfur that the installation in which the fuel is to be burned is equipped in such manner that the requirements of subsection B (1.) will be met.

3. On and after the effective date of this regulation and until the requirements of subsection B (1.) of this regulation are met, no fuel-burning installation with a capacity of 2,000 million or more British thermal units per hour shall burn a fuel or fuels having a higher average sulfur content than the fuel or fuels used in such installation during the 12 months prior to the effective date of this regulation based on a comparable British thermal unit content. For purposes of determining compliance with this subsection B (3.) the average sulfur content of all fuel or fuels used for the 12-month period prior to the effective date of this regulation shall be determined by averaging the sulfur content of all fuel used during such period, on the basis of pounds of sulfur per million British thermal units heating value of the fuel or fuels. This computed average sulfur content shall not be exceeded during any 12-month period after the effective date of this regulation, when determined on the same averaging basis.

Persons responsible for installations subject to section B of this regulation shall furnish the (Head of the air pollution control agency) such data as he may reasonably require to determine whether an installation is being operated in compliance with this subsection B (3.) of this regulation.

C. Restrictions Applicable to Fuel-Burning Installations With a Capacity of Less than 2,000 Million British Thermal Units Per Hour

1. During the months of December____and January_____(years to be inserted by legislative body) no person shall burn or permit the burning of any coal containing more than 1.4* percent sulfur or of any fuel oil containing more than 2.0 percent sulfur, in any fuel-burning installation having a capacity of less than 2,000 million British thermal units per hour.

2. During the months of November and December____ and January and February____ (years to be inserted by legislative body to be 1 year after C (1)) no person shall burn or permit the burning of any coal containing more than 1.4* percent sulfur or of any fuel oil containing more than 2.0 percent sulfur in any fuel-burning installation having a capacity of less than 2,000 million British thermal units per hour.

3. During the months of October, November and December of ____ and January, February and March of ____ (years to be inserted by legislative body, to be 1 year after C (2)) no person shall burn or permit the burning of any coal containing more than 1.4* percent sulfur or of any fuel oil containing 2.0 percent sulfur in a fuel-burning installation having a capacity of less than 2,000 million British thermal units per hour.

---

*Analyzed on a dry basis, but calculated to include normal moisture.

D. Unlawful Conduct

It shall be unlawful for any person to import, sell, offer for sale, expose for sale, exchange, deliver or transport for use and consumption in the (jurisdiction) or to use or consume in (jurisdiction) any fuel which does not meet the requirements of this regulation.

NOTES PERTAINING TO REGULATION X

A steam-electric utility air-use plan committee should be officially appointed to determine means of meeting provision B (1) of regulation X. Such a committee, primarily technical in nature but with an elected public offical as a member ex-officio, would prepare, in not over a 1-year period, a steam-electric utility air-use plan which would indicate the alternate methods available to meet the air-use limitations for this class of sources, and would present costs, methods, and time schedules (not to exceed 5 years) for reaching the air-quality goals.

The values of 2.3 pounds sulfur dioxide per million Btu's, 1.4 percent sulfur coal, and 2.0 percent sulfur oil are based on sulfur limitations needed to reach an air-quality goal of 0.1 ppm, 24-hour average not to be exceeded over 1 percent of the time during any 3-month period. As such they are themselves goals which could be reached by other means than straight reduction of sulfur content of fuels. For example, the source configuration could be changed to fit the diffusion capacity of the air, or different fuels could be substituted in part to fit the diffusion characteristics of the air. Since the air-use plan and percent reduction are based on fuels currently in use in the urbanized area, with fuel oil having a sulfur content of 1.6 percent, the percent should not be increased until the sulfur ascribed to other fuel has decreased proportionately.

A 5- to 10-year period is suggested for meeting provision C fully with major accomplishments by the end of 5 years, and yearly review and step-at-a-time action by the governmental subdivisions involved. The phased approach to implementing fuel changes is based on the air pollution characteristics of the area. If economic, market, labor, or other considerations indicate, it would, of course, be desirable to have uniform requirements for the entire year. In that way the regulatory program would be materially simplified.

Regulation XI. INFORMATION ON SALES OF FUELS TO BE PROVIDED AND MAINTAINED

A. Tickets to be Furnished and Retained

Every delivery of coal or residual fuel oil when first delivered to a consumer or wholesaler in the jurisdiction must be accompanied by a ticket prepared in triplicate and containing at least the name and address of the seller and the buyer; the grade of fuel; and the source of the fuel, which must be an approved source. Tickets on delivery of coal shall also show the ash content of the coal. One copy of each ticket shall be kept by the person delivering the fuel and be retained for 1 year; one copy is to be given to the recipient of the fuel to be retained for 1 year; and, upon request, within 30 days after delivery of the fuel, the delivering party shall mail one copy to the (air pollution control agency).

B. Lists May Be Published

The (Head of the Air Pollution Control Agency) is authorized to publish lists of approved sources or descriptive lists of fuels available in the area which meet the requirements of regulations.

NOTE PERTAINING TO REGULATION XI

Regulation XI is designed to supplement the type of fuel-control system now in operation in the City of St. Louis. It is not complete in itself.

Regulation XII. CERTAIN COALS TO BE WASHED

A. Certain Coals to be Washed

It shall be unlawful for any person to import, sell, offer for sale, expose for sale, exchange, deliver or transport for use and consumption in the (jurisdiction) or to use or consume in the (jurisdiction) any coal containing in excess of 2 percent sulfur or 12 percent ash on a dry basis as mined, before importation, sale, transportation, or use in the (jurisdiction) shall have been cleaned by a process known as washing so that it shall contain no more than 12 percent ash on a dry basis. The term "washing" is meant to include purifying, cleaning, or removing impurities from coal by mechanical process, regardless of cleaning medium used.

B. Testing Methods

The method for determining ash and sulfur content of coal shall be as described in American Society for Testing Materials D-271-64, Standard Methods of Laboratory Sampling and Analysis of Coal and Coke, or equivalent method approved by the (Head of the air pollution control agency) which publication is hereby made a part of this regulation by reference.

C. Samples May Be Taken

The (Head of the air pollution control agency) is authorized to take samples of any coal at any reasonable time or place for purposes of determining compliance with this regulation.

D. Exception

This regulation shall not apply if a person proposing to use unwashed coal can show that the emission of sulfur dioxide from the plant in which the coal is to be burned will emit no more than 2.3 pounds of sulfur dioxide per million Btu's of heat input to the installation and that emission of particulate matter will be no more than that allowed in regulation II section A (3).

Regulation XIII. EMISSION OF CERTAIN SETTLEABLE ACIDS AND ALKALINE SUBSTANCES RESTRICTED

A. General Provisions

This regulation shall apply to all emissions from any source or any premises.

B. Method of Measurement

1. The fallout sampling devices used in determining compliance with this regulation shall consist of circular glass dishes 15 centimeters in diameter. The dishes shall be supported on a nearly horizontal surface not larger than the dish. The dish bottom shall be at least 3 feet above the earth or other surface on which its support is resting. The dish shall be coated with a solution of thymol blue, ammonia water solution and gelatin dried to a yellow color in a vacuum oven at room temperature. Prepared dishes shall be stored in a desiccator at 40 percent relative humidity, or in plastic bags.

2. Fallout sampling devices shall be put in place at one or more locations up-wind and down-wind of a premises at locations beyond the premises on which a source or sources are located. The devices shall be left exposed to substances settling out of the ambient air for a period of 1 hour. The presence of red-colored spots visible to the naked eye on the samplers used to measure fallout of acidic substances shall be construed to mean that acidic substances have settled out of the air. The presence of blue-colored spots visible to the naked eve on the samplers used to measure fallout of alkaline substances shall be construed to mean that alkaline substances have settled out of the air. The number of spots visible on samplers exposed up-wind of a premises is to be subtracted from the number of spots visible on samplers exposed down-wind of the same premises. The difference in the number of spots, if any, shall be construed to be attributable to emissions occurring on the premises under investigation.

3. In lieu of the test methods specified in B (1) and B (2) any other method approved by the (Head of the air pollution control agency) may be used.

C. Emissions Restricted

1. No person shall cause or permit the emission from any source or premises of substances having acidic or alkaline properties in such manner and amounts that the fallout rate of acidic or alkaline substances, at any place where an adverse effect could occur down-wind of such source or premises greater than 1.2 times the fallout rate of acidic or alkaline substances up-wind of the same source or premises, as measured in the manner described in Section B of this regulation.

2. No person shall cause or permit the emission from any source or premises of substances having alkaline properties in such manner and amounts that the fallout rate of alkaline substances at any place where an adverse effect could occur down-wind of such source or premises is greater than 1.2 times the difference in the fallout rate of alkaline substances up-wind and down-wind of the same source or premises, as measured in the manner described in Section B of this regulation.

Regulation XIV. EMISSION OF CERTAIN SULFUR COMPOUNDS RESTRICTED

A. General Provisions

1. Section B of this regulation shall apply to all emissions except those in which both

   a. Fuel is burned primarily to produce heat, and

   b. Sulfur compound emission is due primarily to the sulfur in the fuel burned.

2. Sections C and D shall apply to all emissions from any source or sources whatsoever.

3. The method of measuring sulfur trioxide, sulfuric acid, or any combination thereof in stack gases shall be:

   a. Particulates (H_2SO_4 - acid mists)

   Ref. "Atmospheric Emissions from Sulfuric Acid Manufacturing Processes."

   Public Health Service Publ. 999-AP-13. Appendix B, 61-6.

   (Modified Monsanto Company Method)*

---

*Secondary reference for industrial emission sampling and analysis for particulates (sulfuric acid - acid mists), W. F. Patton, J. A. Brink "New Equipment and Techniques for Sampling Chemical Process Gases." J. Air Poll. Control Assoc. 13, 162-66 (April 1963).

b. Gaseous (SO_3 - SO_2)

Ref. "Atmospheric Emissions from Sulfuric Acid Manufacturing Processes."

Public Health Service Publ. 999-AP-13. Appendix B, 85-7.

(Shell Development Co. Method)*

The method of measuring sulfur dioxide in stack gases shall be:

Gaseous (SO_3 - SO_2)

Ref. "Atmospheric Emissions From Sulfuric Acid Manufacturing Processes."

Public Health Service Publ. 999-AP-13. Appendix B, page 85-7.

(Shell Development Co. method)

The method of measuring sulfur trioxide and sulfuric acid or any combination thereof suspended in the ambient atmosphere shall be:

Particulate (H_2SO_4)

Ref. B. T. Commins. "Determination of Particulate Acid in Town Air."

Analyst. 88: 364-67. (May 1963)

The method of measuring sulfur dioxide in the ambient atmosphere shall be:

Gaseous (SO_2) colorimetric

Ref. "Selected Methods for the Measurement of Air Pollutants"

Public Health Service Publ. No. 999-AP-11

"Determination of Sulfur Dioxide: West and Gaeke Method - p. A1-5 (May 1965).

Gaseous (SO_2) Conductimetric

"ASTM Standards on Methods of Atmospheric Sampling and Analysis," 2nd edition, Method D 1355-60, Method A, American Society for Testing Materials, 1916 Race St., Philadelphia, Pa.

4. Other test methods approved by the (Head of the air pollution control agency) may be used. The publications describing methods of measurement specified in this Section A are hereby made a part of this regulation by reference.

---

*Secondary reference for industrial emission sampling and analysis for gases (sulfur trioxide and sulfur dioxide) "Determination of Sulfur Dioxide and Sulfur Trioxide in Stack Gases," Emeryville Method Ser. 4S16/59a. Anal. Dept Shell Development Co., Emeryville, Calif. (1959).

B. Concentration of Sulfur Compounds in Emissions Restricted

1. No person shall cause or permit the emission into the atmosphere from any existing source specified in subsection A (1) of this regulation, gases containing more than 2,000 parts per million by volume of sulfur dioxide or 300 parts per million by volume of sulfur dioxide from any new source.

2. No person shall cause or permit the emission into the atmosphere from any source specified in subsection A (1) of this regulation, gases containing more than 70 milligrams per cubic meter of sulfuric acid, sulfur trioxide, or any combination thereof or 35 milligrams per cubic meter of sulfuric acid, sulfur trioxide or any combination thereof from any new source (expressed as sulfuric acid).

C. Emission of Sulfur Compounds in Certain Amounts and Manner Restricted

1. No person shall cause or permit the emission of sulfur dioxide from any premises in such manner and amounts that the concentrations and frequencies attributable to such emission exceed those shown in the following table in the ambient air at any occupied place beyond the premises on which the source is located.

Concentration (by volume)	Averaging time	Maximum allowable frequency
0.25 ppm or more	5 minutes	Once in any 8 hours
0.10 ppm or more	1 hour	Once in any 4 days
0.05 ppm or more	24 hours	Once in any 90 days

2. No person shall cause or permit the emission of sulfuric acid, sulfur trioxide, or any combination thereof from any premises in such manner and amounts that the concentrations and frequencies attributable to such emission exceed those shown in the following table in the ambient air at any place where people live, work or congregate beyond the premises on which the source is located.

Concentration* of sulfuric acid or sulfur trioxide or any combination thereof	Averaging time	Maximum allowable frequency
0.03 mg/m^3 or more	30 minutes or more	Once in any 48 hours
0.01 mg/m^3 or more	24 hours	Once in any 90 days

3. No person shall cause or permit the emission of hydrogen sulfide from any premises in such manner and amounts that the concentrations attributable to such

---

*Milligrams per cubic meter at standard conditions, measured and calculated as sulfuric acid.

emissions in the ambient air at any occupied place beyond the premises on which the source is located exceed 0.03 part per million by volume for any averaging period of 30 or more minutes on more than two occasions in any 5 days.

D. More Restrictive Limitation to Apply

In any situation in which more than one requirement of this regulation is applicable, the most restrictive provision shall govern.

Regulation XV. ADDITIONAL AIR-QUALITY CONTROL MEASURES MAY BE REQUIRED WHEN SOURCES ARE CLUSTERED IN A SMALL LAND AREA

A. Areas to Which This Regulation Applies

1. This regulation shall apply to areas in which there are one or more existing major sources and/or proposed new major sources of particulate matter in any circular area with a diameter of 2 miles from which the sum of particulate emissions allowed from major sources by regulations of general application are or would be greater than 2,000 tons per year or 500 pounds per hour. For purposes of this regulation, "major sources" include coal-burning units with a heat input capacity of 100 million or more Btu's per hour, refuse-burning plants with a refuse-burning capacity of 5 tons or more per hour, and industrial processes having a process weight rate of 10 tons or more per hour.

2. This regulation shall apply in areas in which there are one or more existing major sources and/or proposed new major sources of sulfur dioxide in any circular area with a diameter of 2 miles from which the sum of sulfur dioxide emissions from major sources allowed by regulations of general application are or would be greater than 1,000 tons for any consecutive 3 months or 1,000 pounds per hour. For purposes of this regulation, "Major sources" include coal- or oil-burning units with a heat input of 100 million or more Btu's per hour and industrial processes which emit 1 ton or more of sulfur dioxide per day.

B. (Agency) May Prescribe More Restrictive Air-Quality Control Measures

1. In areas where this regulation applies, as specified in Section A herein, the (air pollution control agency) may prescribe air-quality control requirements that are more restrictive and more extensive than provided in regulations of general application. Such measures shall provide for air-resource and land-use management within these areas for the purpose of obtaining the best feasible air-quality in the particular area and for the (jurisdiction) as a whole, consistent with air-quality standards prescribed by regulations or otherwise.

The air-quality control measures prescribed by the (Head of the air pollution control agency) may include, without limiting the same, additional reduction of emissions, modifications of fuel or process material, specified operating time schedules, use of tall stacks, relocation of sources, and other measures. In the event that a proposed new installation will cause the sum of allowable emissions to exceed those given in Section A herein and thus make this regulation apply, only the proposed new plant shall be subject to more restrictive or extensive requirements. (These requirements will be issued as a special use permit issued by the appropriate legislative procedure in the jurisdiction taking into account items in C (a)).

2. In considering the need for the nature of any air-quality control measures to be imposed which are more restrictive or more extensive than those provided in regulations of general application the (Head of the air pollution control agency) shall consider, among others, such matters as: (a) dispersion of emissions; (b) ability of the atmosphere to disperse pollutants; (c) existing and anticipated land-use; (d) stack heights; (e) existing and anticipated air-quality; (f) existing and anticipated emissions; (g) expected service life of sources; (h) cost of additional control measures; and (i) feasibility and impact of various possible ways to preserve or improve air-quality. To the extent feasible, the (Head of the air pollution control agency) shall confer and work with all persons who would be affected by any special air-quality control measures.

NOTE PERTAINING TO REGULATION XV

The air pollution regulations of (jurisdiction) are designed to achieve certain air-quality in the general atmosphere. In most cases, the generally applicable emission control and other regulations are adequate for these purposes. However, in a few cases where one or more pollution sources are, or will be, located in a relatively small area, compliance with regulations of general application may not result in satisfactory air-quality. Since it is not feasible to write regulations which will be suitable in each such special case, this regulation is to provide a formalized procedure for arriving at any necessary more restrictive air-quality control measures needed to ensure satisfactory air-quality in the most equitable manner possible.

Regulation XVI. VARIANCES

A. Any person subject to the air pollution regulations of the (air pollution control agency) may apply to the (Head of the air pollution control agency) for a variance from such regulations or any order of the (Head of the air pollution control agency). The application shall be filed on forms provided by the (Head of the air pollution control agency) who may require submission of such information as he may reasonably require to bring out all pertinent facts in the case. The (Head of the air pollution control agency) shall examine the application and all pertinent facts relating thereto and promptly transmit the application along with his findings, recommendations, and records of the matter to the (Body authorized to grant variances). The (Body authorized to grant variances), within 20 days, shall conduct a hearing on the matter.

The (Head of the air pollution control agency) may also request and he shall be granted a hearing before the (Body authorized to grant variances) on any matter involving a variance.

B. The (Body authorized to grant variances) shall serve notice of the time and place of a hearing on a variance upon the applicant, if any, and upon the (Head of the air pollution control agency), not less than 10 days prior to such hearing.

C. The (Body authorized to grant variances) may grant a variance from any regulation or order of the (Head of the air pollution control agency) if it finds that compliance with the regulation or order from which a variance is sought would produce serious hardship without a corresponding benefit or advantage to the people. The (Body authorized to grant variances) shall exercise a wide discretion in weighing the equities involved in each case.

D. The (Body authorized to grant variances) may prescribe other and different requirements not more onerous, applicable to any situation for which a variance is sought. However, no variance may permit or authorize the maintenance of a nuisance, or a danger to public health or safety.

E. Variances shall be granted by the (air pollution agency) for such periods of time and upon such conditions as permitted by applicable laws. Such variance may be renewed provided a request for renewal is submitted by the applicant to the (Head of the air pollution control agency). If the (Head of the air pollution control agency) approves of the renewal, no hearing need be held. If he disapproves, the (Body authorized to grant variances) shall conduct a new hearing. At such hearing, the (Body authorized to grant variances) shall decide whether the variance should be renewed, revoked, or modified.

F. The (Body authorized to grant variances) may, after a hearing, revoke or modify any variance it has issued, at any time.

Regulation XVII. CONTROL OF ODORS IN THE AMBIENT AIR

A. No person shall emit odorous matter such as to cause an "objectionable" odor:

1. On or adjacent to residential, recreational, institutional, retail, sales, hotel or educational premises.

2. On or adjacent to industrial premises when air containing such odorous matter is diluted with 20 or more volumes of odor-free air.

3. On or adjacent to premises other than in 1 and 2 when air containing such odorous matter is diluted with four or more volumes of odor-free air.

B. The above requirement shall apply only to "objectionable" odors. An odor will be deemed objectionable when 15 percent or more of the people exposed to it believe it to be objectionable in usual places of occupancy. Sample size to be at least 20 people or 75 percent of those exposed if fewer than 20 people are exposed.

Regulation XVIII. CONTROL OF ODORS FROM PROCESSING OF ANIMAL MATTER

A. General

1. For purposes of this regulation the word "reduction" is defined as any heated process, including rendering, cooking, drying, dehydrating, digesting, evaporating, and protein concentrating.

2. The provisions of this regulation shall not apply to any device, machine, equipment, or other contrivance used exclusively for the processing of food for human consumption.

B. Odor Control Equipment Required on Reduction Processes

1. No person shall operate or use any device, machine, equipment or other contrivance for the reduction of animal matter unless all gases, vapors, and gas-entrained effluents from such facility are incinerated at a temperature of not less than 1,200 degrees Fahrenheit for a period of not less than 0.3 second, or processed in such manner as determined by the (Head of the air pollution control agency) to be equally or more effective for the purpose of air pollution control.

A person incinerating or processing gases, vapors or gas-entrained effluents pursuant to this rule shall provide, properly install and maintain, in good working order and in operation, devices as specified by the (Head of the air pollution control agency) for indicating temperature, pressure, or other operating conditions.

C. Other Odor Control Measures Required

1. Effective devices and/or measures shall be installed and operated such that no vent, exhaust pipe, blowoff pipe or opening of any kind shall discharge into the outdoor air any odorous matter, vapors, gases, dusts or any combination thereof which create odors or other nuisances in the neighborhood of the plant.

2. Odor-producing materials shall be confined and handled in a manner such that odors produced within or outside the plant from such materials are controlled. Accumulation of odor-producing materials resulting from spillage or other escape shall not be permitted.

3. Odor-bearing gases, vapors, fumes, or dusts arising from materials in process shall be confined at the point of origin so as to prevent liberation of odorous matter into the work room, and the confined gases, vapors, fumes, or dusts shall be treated before discharge to the atmosphere, as required in subsection C (1).

D. Enclosure of Building May be Required

When dust, fumes, gases, mist, odorous matter, vapors, or any combination thereof escape from a building used for processing of animal matter in such manner and amount as to cause a nuisance or to violate the odor control regulation of the (jurisdiction), the (Head of the air pollution control agency) may order that the building or buildings in which processing, handling and storage are done be tightly closed and ventilated in such a way that all air and gases and air - or gas-borne material leaving the building are treated by incineration or other effective means for removal or destruction of odorous matter or other air contaminants before discharge to the open air.

Regulation XIX. CONTROL OF HYDROGEN SULFIDE EMISSIONS

No person shall emit hydrogen sulfide in quantities which will cause the following concentrations to be exceeded at any place outside the premises where emitted:

1. 0.05 ppm 1/2-hour average not to be exceeded over two times per year.

2. 0.03 ppm 1/2-hour average not to be exceeded over two times in any 5-consecutive-day period.

Regulation XX. EMISSION OF VISIBLE AIR CONTAMINANTS FROM INTERNAL COMBUSTION ENGINES

No person shall cause or permit the emission of visible air contaminants for the internal combustion engine of:

1. Portable or stationary equipment for longer than 10 consecutive seconds; or

2. A motor vehicle while the vehicle is stationary for longer than 10 seconds; or

3. A motor vehicle after the vehicle has moved more than 100 yards from a place where the vehicle was stationary.

Regulation XXI. APPROVAL OF PLANNED INSTALLATIONS, LAND-USE PLANS, AND ZONING REGULATIONS REQUIRED

A. Review of Plans and Approval

1. The (building department or other office responsible) shall not issue a permit for the erection, construction, reconstruction, alteration or occupancy of any building or structure when the plans and specifications for such structure or occupancy include any fuel-burning or refuse-burning device, or any chimney or smoke stack, or the occupancy of any building for industrial purposes, until such plans and specifications have been submitted to the (Head of the air pollution control agency) and approved by him within 30 days as making adequate provisions for meeting the requirements of this ordinance. If the (Head of the air pollution control agency) does not submit his recommendations to the (building department or other office responsible) within 30 days, the plans or specifications shall be deemed approved.

B. Planning Agency Land-Use Plans - Preparation and Approval

1. Planning agencies will, in preparing land-use plans, obtain and use information supplied by the (air pollution agency) concerning:

a. air-quality

b. air pollutant emissions

c. air pollutant meteorology

d. air-quality goals

e. air pollution effects

2. The (air pollution agency) will review all land-use plans prior to formal adoption and prepare recommendations that must be adequately considered in the plan adoption process.

C. Zoning Agency Regulations - Preparation and Approval

1. Zoning control agencies will, in preparing regulations, obtain and use information supplied by the (air pollution agency) concerning:

a. air-quality

b. air pollutant emissions

c. air pollution meteorology

d. air-quality goals.

e. air pollution effects

2. The (air pollution agency) will review all zoning regulations prior to formal adoption and prepare recommendations that must be adequately considered in the regulation adoption process.

Regulation XXII. AIR POLLUTION NUISANCES PROHIBITED

A. No person shall cause or permit the discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public or which endanger the comfort, repose, health, or safety of any such persons or the public or which cause or have a tendency to cause injury or damage to business or property.

B. Nothing in any other regulation concerning emission of air contaminants or any other regulation relating to air pollution shall in any manner be construed as authorizing or legalizing the creation or maintenance of a nuisance as described in section A of this regulation.

Regulation XXIII. MEASUREMENT OF EMISSIONS OF AIR CONTAMINANTS

A. Responsible Persons to Have Tests Made

The (Head of the air pollution control agency) may require any person responsible for emission of air contaminants to make or have made tests to determine the emission of air contaminants from any source, whenever the (Head of the air pollution control agency) has reason to believe that an emission in excess of that allowed by an air pollution regulation of the (air pollution control agency) is occuring. The (Head of the air pollution control agency) may specify testing methods to be used, in accordance with good professional practice. The (Head of the air pollution control agency) may observe the testing. All tests shall be conducted by reputable, qualified personnel. The (Head of the air pollution control agency) shall be given a copy of the test results in writing and signed by the person responsible for the tests.

B. (Head of the Air Pollution Control Agency) May Make Tests

The (Head of the air pollution control agency) may conduct tests of emissions of air contaminants from any source. Upon request of the (Head of the air pollution control agency), the person responsible for the source to be tested shall provide necessary holes in stacks or ducts and such other safe and proper sampling and testing facilities, exclusive of instruments and sensing devices as may be necessary for proper determination of the emission of air contaminants.

Regulation XXIV. SUBMISSION OF EMISSION INFORMATION - AUTHORITY

The (Head of the air pollution agency) may require the submission of air pollutant information from any or all potential sources for purposes of maintaining an air pollutant emission inventory.

Regulation XXV. REQUIREMENTS FOR CONSTRUCTION OF NEW GASOLINE STORAGE FACILITIES

A. General

1. For purposes of this regulation, the term "gasoline" is defined as petroleum distillate having a Reid vapor pressure of 4 pounds or greater.

2. For purposes of this regulation, the term "submerged fill pipe" is defined as any fill pipe the discharge opening of which is entirely submerged when the

liquid level is 6 inches above the bottom of the tank. "Submerged fill pipe" when applied to a tank which is loaded from the side is defined as any fill pipe the discharge opening of which is entirely submerged when the liquid level is 18 inches above the bottom of the tank.

B. Petroleum Storage Tanks

1. After the effective date of this regulation, no person shall build or install or permit the building or installation of any stationary tank, reservior or other container of more than 40,000 gallons capacity which will or might be used for storage of any petroleum distillate having a vapor pressure of 1.5 pounds per square inch absolute or greater under actual storage conditions, unless such tank, reservoir or other container is to be a pressure tank capable of maintaining working pressures sufficient at all times to prevent hydrocarbon vapor or gas loss to the atmosphere or is designed, and will be built and equipped with one of the following vapor loss control devices:

a. A floating roof, consisting of a pontoon-type or double-deck-type roof, which will rest on the surface of the liquid contents and be equipped with a closure seal, or seals, to close the space between the roof edge and tank wall. The control equipment to be provided for in this subsection B (1) shall not be permitted if the gasoline or petroleum distillate to be stored will have a vapor pressure of 12 pounds per square inch absolute or greater under actual storage conditions.

b. All tank gauging and sampling devices shall be built so as to be gas-tight except when gauging or sampling is to take place.

c. Other equipment or means of equal efficiency for purposes of air pollution control as may be approved by the (Head of the air pollution control agency).

C. Submerged Fill Pipes Required

1. After the effective date of this regulation, no person shall build or install or permit the building or installation of a stationary gasoline storage tank with a capacity of 250 gallons or more unless such tank is equipped with a permanent submerged fill pipe or is a pressure tank as described in subsection B (1) of this regulation, or is fitted with a vapor recovery system as described in subsection B (1) (a) of this regulation.

Regulation XXVI. ENTRY ONTO PREMISES - AUTHORITY

In the general performance of its duties the (air pollution agency and its authorized personnel) are hereby authorized to enter at all reasonable hours upon and into any buildings, establishments, premises, and enclosures in or from which they have reason to believe the provisions of this (ordinance) are being violated, to inspect or examine such buildings, establishments, premises or enclosures, and to collect and preserve evidence of all facts as to violations of this (ordinance).

Regulation XXVII. CIRCUMVENTION

No person shall cause or permit the installation or use of any device or any means which without resulting in reduction in the total amount of air contaminant emitted, conceals or dilutes an emission of air contaminant which would otherwise violate an air pollution control regulation. This regulation shall not apply when the only violation involved is violation of a regulation based on concentration or presence of one or more air contaminants at locations beyond the premises on which a source or sources are located.

Note: Operating Permit Systems and Registration Systems

The legislative body enacting ordinances should consider the merits of permit and registration systems for program administration and select the system that meets the jurisdiction's program needs and objectives.

USE OF SUGGESTED ORDINANCE PROVISIONS IN APPENDIX B AFTER RELEASE OF DRAFT REPORT ON MAY 30, 1966, UNTIL JULY 1967

Since the release of the draft of Volume VIII of the Interstate Air Pollution Study, the suggested ordinance provisions have been put to important use. They have undergone some modifications in this process to relate specifically to the realities of the jurisdictions applying them. When thought of in terms of reaching the air quality goals, some of these modifications have strengthened the ordinance provisions and some have not. The actions taken have all been carried on independently by the responsible agencies and political jurisdictions and therefore are indicative of both the positions and capabilities of local governments in fashioning their own ordinances.

For the purpose of brevity, only major changes to the suggested ordinance provisions given in Appendix B are reported. Minor additions, deletions, and alterations are not covered.

EAST-WEST GATEWAY COORDINATING COUNCIL ACTION

The East-West Gateway Coordinating Council was formed in the St. Louis area during the time that the Interstate Air Pollution Study project was in operation. Its membership is composed of six elected officials from the Illinois part and six from the Missouri part of the St. Louis Standard Metropolitan Statistical Area. A 13th member represents the Bi-State Development Agency. The Council's purpose is to deal with regional problems such as transportation. The Council has an executive secretary with an office in East St. Louis, Illinois.

The Interstate Air Pollution Study project agreement states that the project Executive Committee members and their agencies "recognize the need for coordination and continuity of air pollution activities and indicate their intention of meeting this need..until such time as a successor body might be formed." As a result of this project agreement statement, agencies and individuals in the St. Louis area knew that the project Executive Committee was looking for a permanent "home" for its regional activities. For this reason, it was quite logical for the East-West Gateway Coordinating Council members to informally indicate an interest in providing such a "home" and for a letter to be sent from the study Executive Committee to the Council formally asking its interest and intent. After considerable deliberation the Council formally offered to provide a temporary base for the project Executive Committee. In addition, in July 1966, the Council decided to hold public hearing on the suggested ordinance provisions (Appendix B). These hearings were scheduled for September and October. All 13 of the Council's members formed the hearing board which was chaired by the Council's executive secretary. The hearings lasted a full 3 days and took place in St. Louis, Missouri; Edwardsville, Illinois;

and Clayton, Missouri. The hearings publicized the study report and the recommendations and findings widely. Although they concentrated on controversial aspects and the discussion was limited largely to the suggested ordinance provisions, they uncovered a considerable area of truth that the technically oriented project Executive Committee could not bring forth. Following these three hearings and some additional meetings, the Technical Representatives of the Governmental Agencies of the Interstate Air Pollution Study revised the suggested ordinance provisions, and the Industrial Waste Control Council, an industry sponsored group, wrote a set of ordinance provisions. With these two sets of ordinance provisions at their disposal, the East-West Gateway Coordinating Council approved a model ordinance. Later the City of St. Louis, St. Louis County, enacted ordinances and the states of Illinois and Missouri adopted rules and regulations to control air pollution in the portions of the area under their jurisdiction.

The two sets of ordinance provisions, the model ordinance, the two ordinances and two sets of rules and regulations are discussed in the following sections in respect to their differences from the ordinance provisions in the first part of the Appendix.

REVISED PROPOSAL BY TECHNICAL REPRESENTATIVES OF GOVERNMENTAL AGENCIES OF INTERSTATE AIR POLLUTION STUDY

The revised proposal was prepared on November 22, 1966, and included the following changes:

Regulation II - Maximum Allowable Emission of Particulate Matter from Fuel Burning Equipment Used for Indirect Heating

This regulation is based on the American Society of Mechanical Engineers publication "Recommended Guide for the Control of Dust Emissions - Combustion for Indirect Heat Exchangers" (ASME Standard No. APS-1; 1966); however, the following modifications were included:

1. The stack height as determined by the ASME method is reduced by the difference in elevation, if any, between the elevation of the ground at the base of the stack or stacks and any other point having a higher elevation and lying within 1 mile of the stack. A stack height of 50 feet is used to determine the maximum allowable emission rate for installations having stacks less then 50 feet high.

2. A maximum allowable emission of 0.6 pound of particulate matter per million Btu of heat input is used in place of the ASME proposal of 0.8 pound of particulate matter per million Btu of heat input.

3. All installations having a total heat input rate of 5 million Btu or more per hour must be equipped with particulate matter emission control equipment that will remove at least 85 percent of the particulate matter in the gases arising from the installation.

Regulation X - Restrictions of Emissions of Sulfur Dioxide from Use of Fuel

Under Section C, No. 1, the time periods December 1967 and January 1968 were added. The sulfur limit for coal was changed from 1.4 to 2.25 percent.

Under Section C, No. 2, the time periods November and December 1968 and January and February 1969 were added. The sulfur limit for coal was changed from 1.4 to 2.25 percent.

Under Section C, No. 3, the time periods October - December 1969 and January - March 1970 were added. The sulfur limit for coal was changed from 1.4 to 2.25 percent.

Regulation XIV - Emission of Certain Sulfur Compounds Restricted

Under Section B, No. 1, the sulfur dioxide emission limitation for new sources was changed from 300 to 500 ppm.

Regulation XIX - Emission of Visible Air Contaminants from Motor Vehicles

This regulation was changed so as to prohibit the emission of visible air contaminants from motor vehicles of a shade or density equal to or darker than that designated as No. 1 on the Ringelmann chart, or of such opacity as to obsure an observer's view to an equivalent degree. Emissions of visible air contaminants having a shade or density not darker than that designated as No. 2 on the Ringelmann Chart or of such opacity as to obsure an observer's view to an equivalent degree is permitted for a period not to exceed 5 seconds.

INDUSTRIAL WASTE CONTROL COUNCIL PROPOSAL FOR A CLEAN AIR PROGRAM

The Industrial Waste Control Council presented its proposed program on November 15, 1966. The proposal was divided into two parts. The first part contained administrative provisions for both Missouri and Illinois, and the second part contained the regulations. Regulations I, XVI, XXI, XXII, XXIII, and XXV of Appendix B, which are administrative in nature, were included in the Administrative Section. The major areas of difference in the proposed regulations and those of Appendix B are as follows:

Regulation II - Maximum Allowable Emission of Particulate Matter from Fuel-Burning Equipment Used for Indirect Heating

The ASME Standard APS-1 "Recommended Guide for the Control of Dust Emissions -- Combustion for Indirect Heat Exchangers" was adopted for this regulation with no recommended modifications. Figure 2 of that publication establishes the maximum allowable emission levels.

Regulation IV - Restriction of Emission of Particulate Matter from Industrial Processes

The same process weight limitation as given in Appendix B is used; however, certain processes are excluded. A maximum emission of particulate matter from any source of 0.40 grain per standard cubic foot is permitted instead of the 0.30 grain per standard cubic foot given in Appendix B.

The processes excluded from the process weight limitation are as follows:

1. Catalytic crackers: Existing installations having collection equipment with an overall collection efficiency of 99 percent or better.

2. Cement plants: All installations are allowed a maximum emission of 0.10 grain of particulate matter per standard cubic foot.

3. Existing foundry cupolas and foundry open-hearth furnaces: All existing foundry cupolas and foundry open-hearth furnaces must be equipped with gas-cleaning devices that will meet the following emission limitations:

Process Weight, lb/hr	Maximum allowable discharage, lb/hr
1,000	3.05
2,000	4.70
3,000	6.35
4,000	8.00
5,000	9.65
6,000	11.30
7,000	12.90
8,000	14.30
9,000	15.50
10,000	16.65
12,000	18.70
16,000	21.60
18,000	22.80
20,000	24.00
30,000	30.00
40,000	36.00
50,000	42.00
60,000	48.00
70,000	49.00
80,000	50.50
90,000	51.60
100,000	52.60

4. Blast furnaces: A maximum allowable emission for gases after burning is 0.10 grain of particulate matter per standard cubic foot. A maximum allowable emission for excess gas is 0.25 grain of particulate matter per standard cubic foot, and burning of the gases is required before being discharged.

5. By-product coke plants: Smoke emitted during charging of the ovens or pushing coke from the ovens is allowed to exceed No. 2 of the Ringelmann chart for a period or periods aggregating not more than 20 minutes in any 60-minute period. Smoke from the doors and frames of the ovens must not exceed No. 2 of the Ringelmann chart.

6. Continuous ferrous cupolas: Those installations constructed subsequent to the enactment of the rules and regulations are limited to a maximum emission rate of 0.20 grain per standard cubic foot.

7. Sintering plants, open-hearth furnaces, electric furnaces, and basic oxygen furnaces: The particulate matter in the discharge gases must not exceed 0.10 grain per standard cubic foot.

Regulation VII - Incinerators

A maximum emission rate of 0.30 grain of particulate matter per standard dry cubic foot of exhaust gases for all sizes of incinerators is permitted.

Regulation VIII - Restriction of Emission of Visible Air Contaminants

No fuel-burning installation is allowed to discharge black smoke of a shade or density equal to or darker than that designated as No. 2 on the Ringelmann chart. Black smoke darker than No. 2 is allowed for a period or periods aggregating not more than 6 minutes in any 60-minute period.

An equivalent opacity limitation is not included.

Regulation X - Restriction of Emissions of Sulfur Dioxide from Use of Fuel

All existing and new combustion installations must burn or be designed to burn the lowest sulfur content fuel that is reasonably available. No specific limitations are given, and factors such as price, firmness of supply, extent of existing pollution, and assurance of supply under adverse weather and natural disaster conditions determine whether the fuel is reasonably available.

Regulation XIII - Emission of Certain Settleable Acids and Alkaline Substances Restricted

This regulation is not included.

Regulation XVIII - Control of Odors from Processing of Animal Matter

The Industrial Waste Control Council omitted this regulation because it is covered under the general odor regulation, "Control of Odors in the Ambient Air."

Regulation XIX - Emission of Visible Air Contaminants from Motor Vehicles

This regulation is not included.

Regulation XX - Approval of Planned Installations, Land-Use Plans, and Zoning Regulations Required

This regulation is not included.

EAST-WEST GATEWAY COORDINATING COUNCIL MODEL ORDINANCE

The East-West Gateway Coordinating Council adopted a model ordinance on January 11, 1967. This model was patterned around the suggested ordinance provisions of Appendix B; however, several changes were made on the basis of the revised proposal by the technical representatives of the governmental agencies of the Interstate Air Pollution Study and the Industrial Waste Control Council proposal.

Regulation II - Maximum Allowable Emission of Particulate Matter from Fuel Burning

The model ordinance includes the same changes as were given above under the revised proposal by the technical representatives of the governmental agencies of the Interstate Air Pollution Study.

Regulation IV - Restriction of Emission of Particulate Matter from Industrial Processes

The model ordinance includes the same changes as were given above under the Industrial Waste Control Council proposal, except that continuous ferrous cupolas are not excluded from the process weight limitation.

Regulation VIII - Restriction of Emission of Visible Air Contaminants

The Ringelmann limitations for black smoke are the same as those in Appendix B; however, they shall not apply to metallurgical fume emissions or measurement of the opacity of noncombustion process emissions. Equivalent opacity units based on the Ringelmann chart can only be used as a method of inspection by the control agency.

Regulation X - Restriction of Emissions of Sulfur Dioxide from Use of Fuel

All fuel burning installations are required to burn coal having a maximum sulfur content of 3.3 percent and fuel oil having a maximum sulfur content of 2.5 percent. The sulfur content of fuel oil is to be reduced by 0.1 percent each year beginning on January 1, 1968, until January 1, 1972, when it will remain at 2.0 percent sulfur.

Regulation XIV - Emission of Certain Sulfur Compounds Restricted

Existing sources are limited to a maximum emission of sulfur dioxide of 2,000 ppm by volume. The 500 ppm of sulfur dioxide by volume restriction for new plants may be adopted after the technology develops and this limit is demonstrated in the United States. The sulfuric acid or sulfur trioxide (expressed as sulfuric acid) emissions are limited to 70 milligrams per cubic meter for the burning of sulfur and 200 milligrams per cubic meter from any other process source.

Regulation XIX - Emission of Visible Air Contaminants from Internal Combustion Engines

This regulation was changed to read the same as the revised proposal of the technical representatives of the governmental agencies of the Interstate Air Pollution Studies.

MISSOURI AIR CONSERVATION COMMISSION RULES AND REGULATIONS FOR ST. LOUIS METROPOLITAN AREA

On February 22, 1967 the Commission adopted rules and regulations that contained essentially the same provisions as the revised proposal of the technical representatives of the governmental agencies of the Interstate Air Pollution Study described earlier. The air-quality goals given in Appendix B were adopted as air quality standards. Minor modifications were as follows:

Regulation II - Maximum Allowable Emission of Particulate Matter from Fuel Burning Equipment Used for Indirect Heating.

The stack height is defined as the upward vertical distance from an elevation 600 feet above mean sea level to the location at which gases passing through the stack enter the atmosphere.

In addition to the modified ASME Standard and the minimum collection efficiency of 85 percent, the Commission also adopted a curve similar to the one proposed in Appendix B, which does not give credit for stack height. The Commission's curve stops at 0.18 pound for each million Btu input for equipment having a capacity rating of 10,000 million Btu or more instead of 0.20 pound as proposed in Appendix B. When two or more of the Missouri provisions are applicable in a particular case, the one resulting in the lowest emission rate shall apply.

Regulation IV - Restrictions of Emissions of Particulate Matter From Industrial Processes

A paragraph included on grey iron jobbing cupolas requires them to be equipped with control equipment and so operated as to remove 85 percent by weight of all the particulate matter in the cupola discharge gases or to release not more than 0.40 grain of particulate matter per standard cubic foot of discharge gas, whichever is more stringent. Incineration of all cupola discharge gases at 1200°F for at least 0.3 second is also required.

Regulation X - Restriction of Emissions of Sulfur Dioxide from Use of Fuel

The sulfur content of coal is limited to 2.0 percent for installations having a capacity of less than 2,000 million Btu heat input. Installations having a capacity of 2,000 million or more Btu per hour must burn fuel containing no more than 2.3 pounds of sulfur dioxide per million Btu heat input 3 years after the effective date of the regulations. Installations having a capacity of less than 2,000 million Btu per hour must burn 2.0 percent sulfur fuel during the following periods:

1. December 1968 and January 1969.
2. November 1960 and February 1970.
3. October 1970 and March 1971 and every year thereafter.

STATE OF ILLINOIS AIR POLLUTION CONTROL BOARD RULES AND REGULATIONS GOVERNING CONTROL OF AIR POLLUTION

Rules and regulations were adopted on March 26, 1965 and amended on March 30, 1967, to control smoke and particulate matter in the State. No provisions were included for the control of gases.

Since the Illinois Board did not follow the format or content of the suggested ordinance provisions, a brief description of that agencies rules and regulations is given below.

Chapter I - Definitions

This chapter gives 52 definitions of terms used in the rules and regulations.

Chapter II - Rules for Controlling Existing Pollution

This chapter requires all manufacturers in the State to submit a letter of intent to the State Air Pollution Control Board. The letter must supply complete information on process equipment, fuel combustion, and emissions to the atmosphere. An air-contaminant emission-reduction program must also be filed with the Board. The intent of this requirement is to schedule over a reasonable period of time either an installation of gas-cleaning devices and/or the replacement and/or alteration of specified facilities so that emissions of air contaminants are reduced to the levels required by the Regulations. The Technical Secretary will review the programs and judge whether they are adequate and reasonable.

Most existing equipment located inside the Standard Metropolitan Statistical Areas (SMSA) must comply with the emission standards for new equipment within 60 days after the effective date of the Regulations or else submit an acceptable emission reduction program.

Most existing equipment located outside the SMSA must comply with the emission standards for new equipment 12 months after the effective date of the Regulations or else submit an acceptable emission reduction program within 6 months of the effective date of the Regulations.

The processes excluded from these requirements are as follows:

1. Catalytic cracking units: The emission standards for new equipment will not apply if gas cleaning devices have an overall efficiency of 99.7 percent.

2. Blast furnaces: This limitation is the same as that proposed by the Industrial Waste Control Council and the East-West Gateway Coordinating Council.

3. Combustion for indirect heating outside SMSA: These installations must meet the ASME Standard No. APS-1, "Recommended Guide for the Control of Dust Emission - Combustion for Indirect Heat Exchangers." A maximum allowable emission of 0.8 pound of particulate per million Btu input regardless of stack height is allowed.

4. Foundries: Small foundries (less than 20,000 pounds per hour) are required to meet the following emission limitations:

Process weight rate, lb/hr	Allowable emissions, lb/hr
1,000	3.05
2,000	4.70
3,000	6.35
4,000	8.00
5,000	9.58
6,000	11.30
7,000	12.90
8,000	14.30
9,000	15.50
10,000	16.65
12,000	18.70
16,000	21.60
18,000	23.40
20,000	25.10

Chapter III - Rules for Control of Emissions from New Equipment

Emissions from the combustion of fuel in new equipment are limited by the ASME Standard No. APS-1, with a maximum allowable emission of 0.6 pound of particulates per million Btu input regardless of stack height.

The Ringelmann chart is used only to evaluate smoke, and is not to be used for determining metallurgical fume emissions or measuring the opacity of noncombustion process emissions. Smoke having an appearance which is No. 2 or darker of the Ringelmann chart is prohibited except during maintenance or a breakdown.

The particulate emissions from most new process equipment is limited according to the process weight as recommended in the suggested ordinance provisions of Appendix B. The installations excluded are as follows:

1. Blast furnaces: All gases discharged to the atmosphere after burning must contain no more than 0.05 grain of particulate matter per standard cubic foot. The

excess gas must be burned before being discharged and contain no more than 0.10 grain of particulate matter per standard cubic foot.

2. By-product coke plants: When charging or pushing coke from a battery of coke ovens, smoke darker than No. 2 of the Ringelmann Chart is permitted for not more than 20-minutes in any 60-minute period.

3. Sintering plants, open-hearth furnaces, electric furnaces, and basic oxygen furnaces: The gas discharged to the atmosphere must contain no more than 0.10 grain of particulate matter per standard cubic foot.

4. Cement kilns: All plants must have gas-cleaning devices that are at least 99.7 percent efficient; however, no discharge gas may contain more than 0.1 grain of particulate matter per standard cubic foot.

5. Incinerators: Incinerators rated at 1,000 or more pounds per hour must not emit gas containing more than 0.2 grain of particulate matter per standard cubic foot adjusted to 50 percent excess air. All other incinerators are limited to 0.35 grain of particulate matter per standard cubic foot.

6. Nonferrous electric furnaces: The process weight limitation does not apply during charging and pouring operations.

7. Food and agriculture and fertilizer product processes: Corn wet-milling process dusts are not limited to process weight if there is proof that it is technically and economically unreasonable to do so. A limit of 0.75 grain per standard cubic foot applies to all new equipment processing material with a specific gravity less than 2.0 and the exit gas has a dew point higher than the ambient air.

CITY OF ST. LOUIS - ST. LOUIS AIR POLLUTION CONTROL ORDINANCE OF 1967

The City of St. Louis adopted its air pollution control ordinance on March 27, 1967. The provisions were almost identical to the revised proposal of the technical representatives of the governmental agencies of the Interstate Air Pollution Study with the following minor exceptions.

A section added to cover existing foundry cupolas requires control equipment with at least an 85 percent collection efficiency or a maximum exit gas concentration of 0.40 grain of particulate matter per standard cubic foot.

The limitation of sulfur content of coal is the same as that adopted by the Missouri Air Conservation Commission.

ST. LOUIS COUNTY - AIR POLLUTION CONTROL CODE

St. Louis County adopted an ordinance on June 15, 1967, which became effective July 5, 1967. It includes by reference, the Rules and Regulations for the St. Louis Metropolitan Area adopted by the Missouri Air Conservation Commission.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1968 O - 319-146